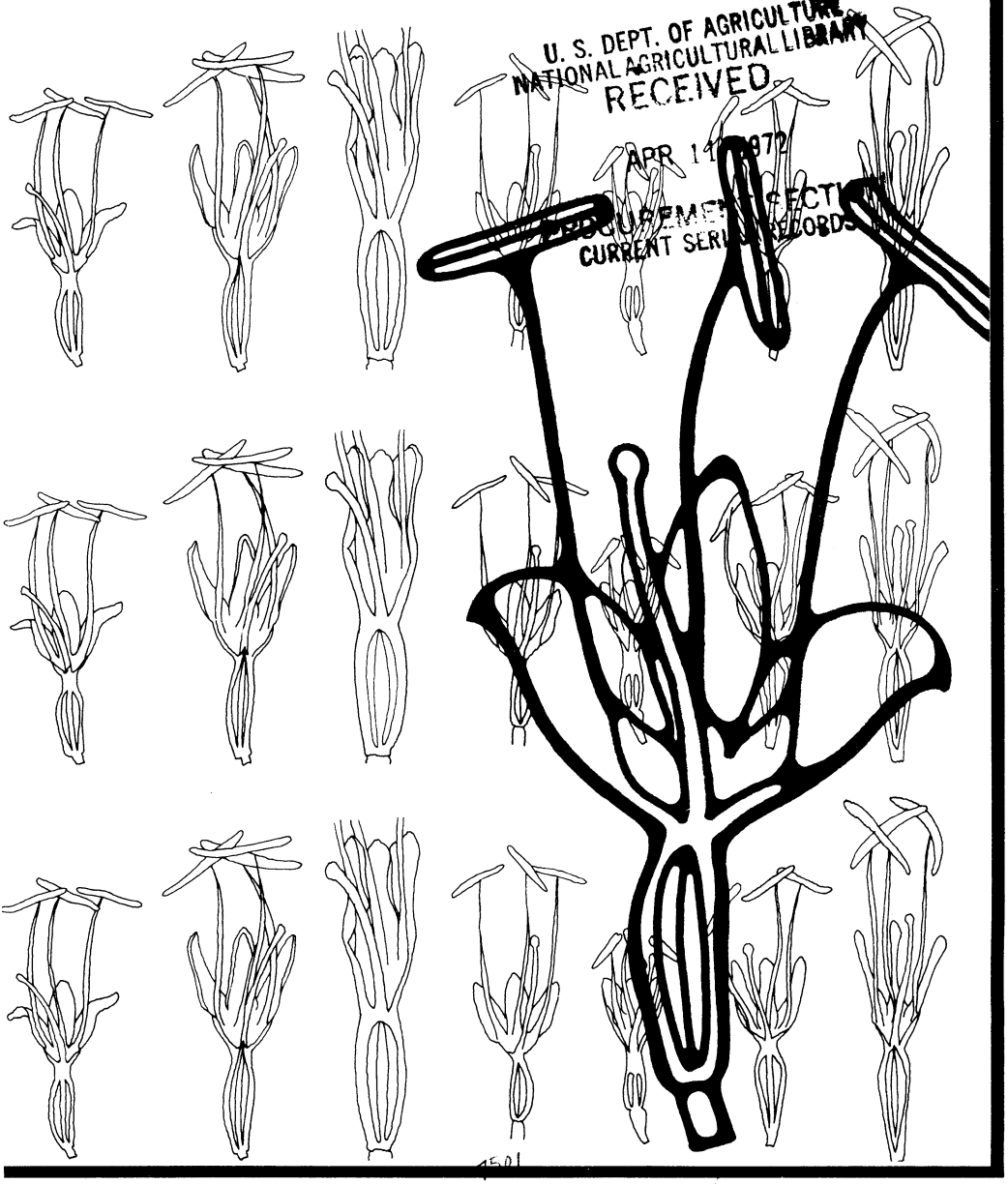
The Agave Family in Sonora

AGRICULTURE HANDBOOK NO. 399



AGRICULTURAL RESEARCH SERVICE · U. S. DEPARTMENT OF AGRICULTURE

THE AGAVE FAMILY in SONORA

Agriculture Handbook No. 399

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

Washington, D.C. Issued March 1972

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402–Price $1.25 (paper cover)
Stock Number 0100–1237

THE AGAVE FAMILY IN SONORA

By HOWARD SCOTT GENTRY, *research botanist*, Plant Science Research Division, Agricultural Research Service

ENVIRONMENTAL SETTING

In Sonora, agaves are scattered like gems in an arborescent matrix. They grow mainly upon the rocky slopes of hills and mountains and are generally lacking in the valleys and on the plains. Hence, the distributional pattern is islandlike. Compared with the massive populations of agaves in Baja California and in the Coahuilan Desert, they are very sparse in Sonora. However, they are distinctly characteristic of the succulent component in the vegetation of our American deserts and arid regions (*42*).[1] Sonora is predominantly a country of open shrub and small tree growth with intervening grasslands. The arborescent growth varies from the widely spaced, drought-adapted shrubs of the northwestern desert to the closely spaced, tropical short-tree forest of the southeastern barrancas and mountains. The whole constitutes a highly varied community of plants, in which agaves are fortuitously deployed.

Agaves occur from sea level to the tops of the higher mountains at elevations of 7,000 to 8,000 feet. They thrive on limestone but they appear to do as well on igneous rocks and other well-drained, nonalkalinic land. One species, *Agave aktites*, is endemic to the coastal sand dunes. Desert species exist with about 5 inches or less annual precipitation and can endure rainless years; montane species receive 30 or more inches of annual precipitation. Nearly all Sonoran agaves are subject to frosts. Very light frosts occur rarely along the southern coast, while freezes are severe in the northeastern mountains, where *A. palmeri* and *A. huachucensis* may be covered with snow.

[1] Italic numbers in parentheses refer to Literature Cited, page 184.

Agaves are heliophytic and xerophytic. They pioneer on hot rock surfaces and the geologically transient rubble of talus and outwash slopes. The crevices of rocks and sheltering thorn shrubs help protect them during the delicate seedling stage when life hangs precariously between recurrent droughts and the wandering feet and teeth of animals. In many desert localities, the survival of agave populations appears dependent upon the nursemaid vegetation, much as Turner and associates found with saguaros (*51*). Seedling survival is enhanced during those unusually favorable rainy periods that occur by decades rather than by yearly seasons. Shreve commented on this with other desert plants (*41*). Once established, the young agave has an inherent hardiness for the rigors of local climate. Its developing armature of teeth and spines and the bitter leaf juices repel animals.

The generative period for sexual progeny is long, 8 to 25 years, and of uncertain issue. Genetic potential and environment appear to have evolved the suckering plantlets, "hijos," for species survival in arid lands. If the monocarpic parent does not leave progeny with its one burst of flowers and seeds, then the vegetative sprouts it produces about the old dry base will have, in another climatic cycle, another chance to leave its variable offspring along the survival line. The immortal genes carry on. Sexual generations in such cases are two, three, or more times longer than the monocarpic habit indicates and exceed the sexual generations of many trees. Because of the infrequency of gene assortment and recombination, evolution in such lines may be very slow. Some agave clusters, as in fairy rings, are perhaps hundreds of years old and still without apparent seeded progeny. I have never seen a wild seedling agave less than 1 year old although I have encountered 2- or 3-year-olds sporadically. This seedling scarcity is not due to lack of seed because most wild agaves produce abundant seed upon maturity. One spike of *Agave chrysoglossa* yielded about 750,000 seeds, as estimated by counting the capsules per inch of the fruiting shaft. If the population near Bacanora is only just maintaining itself, this indicates that only one seed in a half million to a million germinates and grows to maturity.

Many agaves are now known to have extensive ranges and populations, whereas others are relatively rare. Most of the Sonoran species are among the latter. *A. pelona* and *A. zebra* are limited to the rocky heights or slopes of a few northwestern mountains within Sonora. *A. parviflora* and *A. shrevei matapensis* are known only as a few dozen or a few hundred individuals. This apparent rarity may be due to lack of exploration because their ecology indicates they may exist on many of the unbotanized mountains of

northeastern Sonora. *A. subsimplex* is presently rare, having been greatly reduced by the Seri Indians who have eaten it. Because of its palatability to the Warihio Indians who prefer it as a sweet food to all the other agaves in their habitat, *A. jaiboli* has become increasingly rarer during the 30 years I have known it. Man and his animals, which are fond of the young flowering shoots, have probably greatly reduced the native wild populations. See Castetter, Bell, and Grove on Indian uses of the Agaves (*8*).

The widely scattered populations of agave in Sonora consist frequently of small colonies. *A. pacifica* in the coastal thorn forest of the south is an exception. It extends over many miles and numbers thousands of individuals. Plants are not conspicuous unless they are flowering because shrubs generally hide them from view. *A. pacifica* grows on sandy soils and gravelly terraces in rather regularly and widely spaced suckering clumps. This species is also widely dispersed on rocky slopes through the short-tree forest and is the most abundant agave of the Mexican west coast.

A. vilmoriniana, A. pelona, A. ocahui, and *A. multifilifera* are virtually limited to cliffs, where they are out of reach of most larger animals. These cliffdwellers also are generally unarmed, whereas most agaves in open accessible sites have some protection furnished by spines and teeth. Some species contain bitter principles in addition to high sapogenin content that make them unpalatable to many animals and man. The escape habitat, the armature, and toxins all appear to be adaptations of some survival value in the evolution of this genus.

Although the long sexual generation cycle in agave may have slowed the evolution of species, their inherent predilection for rocky sites has resulted in fragmented distributions. Evolution of the colonies to species could have been fostered by their isolation. As other studies have indicated (*19, 34, 36, 45*), mutations and reassortment of genes in isolation have evolved new genotypes, which in time become genetically distinct from former contemporaries, lose gametic compatibility, and evolve eventually as species.

Mountains in Sonora have existed for a long stretch of geologic time. The granitic pediments are precretaceous in age. Some of the limestones are Pennsylvanian and Cretaceous (*59*). Volcanic eruptives, which indicate faulting and differential land movements, are known from the Triassic, Miocene, and Pleistocene. Block faulting and uplift, along with volcanism, created disjunct mountains out of uniform plains. The physiographic evolution involved the Gulf of California (*39*). Several of the coastal mountains appear to have been islands in the Gulf for much of the upper

Tertiary, until they were grounded to the mainland during the Pleistocene by the buildup of the coastal plain, as attrital materials were carried coastward from the weathering Sierra Madre system. Sierra Coloral, Sierra Seri, and the Guaymas monadnoch are examples of these coastal mountains. I have called such land bodies postinsular (*14*, pp. *85–88*).

The disjunct pediments that appear to have been included in the Gulf of California during much of the Upper Tertiary are hachured on the map (fig. 1). Some of the more inland pediments

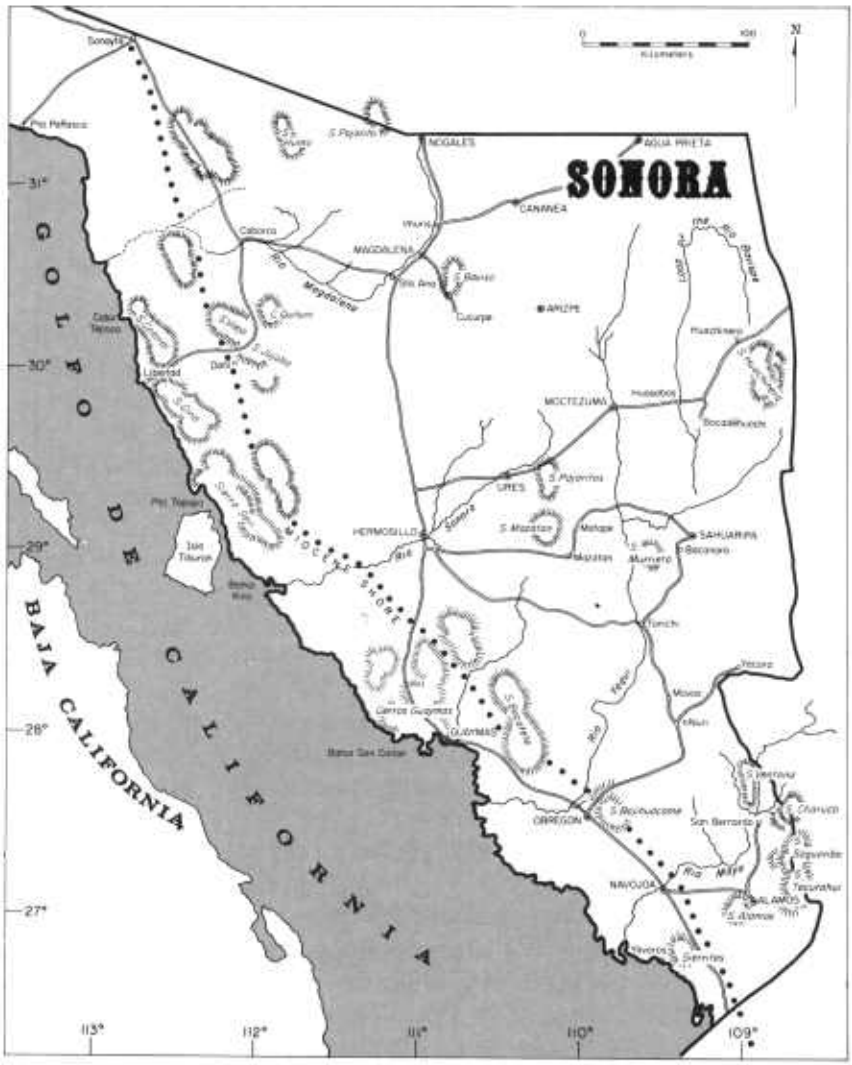


FIGURE 1.—Map of the state of Sonora with the principal plant localities referred to in this handbook.

like Sierra Bojihuacame and the Bacatetes, if not islandic, most probably were maritime headlands. Sierra Bojihuacame appears but little degraded and rather more recent than the others. However, the caverns along its base appear to be wave cut, as in an eustadial period, and marine shells occur on a Pleistocene surface below Recent fills. In drawing the Miocene sea line, I have followed Schuchert (*39*) in principle but not in detail, placing the Miocene Sonoran sea line farther inland. This seems desirable to account for the very large coastal plain buildup during the Pleistocene and the generally emerging coastline. In any case, this shoreline should not be considered as definitive but only to draw attention to the geobotanical evolution indicated.

The yuccas, nolinas, and other genera of the Agavaceae do not express as much geobotanical evolution in their distributions as the agaves. *Yucca arizonica, Hesperaloe nocturna,* and *Nolina bigelovii* are truly endemic; but they are limited to physiographic regions, not to certain isolated mountains. These are regional, not insular, endemic plants. Among continental plants, the palms are among the few groups that rival the agaves in their response to physiographic fractionation. Oceanic islands show many insular endemics among many genera and if we review Trelease's, "Agave in the West Indies" (*50*), we find all of his species endemic to one or a few adjacent islands. Even though we exercised a broader species concept than Trelease, the Caribbean agaves would still show a high degree of insular endemism. The genus appears to have maintained a high rate of speciation under the aegis of isolation.

The evolution of land forms was part of the environmental change operating with climate and associated biota on the genetic versatility of agave to create the rich assortment of agave forms existing in Sonora today. Unfortunately, agaves are unknown as fossils. Although their nondeciduous leaves are not suitable for fossil preservation, their seeds or capsules could conceivably be preserved in compressions, but their topographic situations on rocky uplands provide small chance for internment in sedimentary basins.

To what extent can land differentiation be correlated with speciation? There are many more mountains to climb, more morphology to know, and genetic systems to trace before we can answer such questions. To understand agave relationships, to understand them as species, we must read them and their environments back in time. Then perhaps we can mature a causal philosophy.

ANIMAL ASSOCIATES OF AGAVE

Many animals get food, drink, and shelter from the agaves. Some animals are simply takers but others, including the pollinators, appear to pay for food with biological service. The following notes are based upon my observations during visits to agave populations. While these notes reflect the cursorial nature of my visits, they indicate that agaves are generally beneficial to wildlife and in places where they are abundant, their presence may be critical to the continuance of some animal populations. That copious flower nectar should be a splendid refreshment for animals in the hot, arid deserts. Man is the animal most injurious to the agaves. He not only chops them up and eats them and encourages his domestic animals to do likewise, but also hacks them needlessly and bulldozes them out of his way. His constructive uses of them are discussed in the section, "Uses of Agave and Yucca," page 9.

Bighorn sheep and deer eat the young flowering shoots of agaves. In addition to containing sugars, starches, and other nutrients, these shoots contain abundant water and must be of some importance to these animals, particularly when the flowering shoots appear during dry seasons when desert water tanks are empty and fresh ephemeral vegetation is not available. The leaves are rarely eaten. However, mummified stomachs of extinct ground sloths showed that they fed on leaves of the Agavaceae (*21*).

Pack rats of the genus *Neotoma* frequently live among the thickets of agave. These rodents make their characteristic piles of sticks, thorns, and litter among the protective agave thorns. Their runways may be chewed through the leaf bases and these juicy organs probably supply them with food and moisture. Animal chewings on the fruits and flowers above *Neotoma* dwellings are signs attributable to them also.

Ground squirrels of the genus *Citellus* have been observed eating and carrying off the flowers and green fruits of agaves. These rodents forage out hundreds of feet from their burrows and they may disperse seeds in this activity.

The desert spermophiles and the kangaroo rats of the genus *Dipodomys* have runways around agave plants. Although it is not certainly known if these rodents eat the seeds or other organs of agaves, these armored plants afford them a measure of protection when the rodents must elude preying foxes, coyotes, bobcats, and birds of prey by night and day.

Pocket gophers of the genus *Thomomys* have proved very damaging in the agave garden. They tunnel up through the bases of the plants and eat out the central meristematic tissue. They work

from below and within, out of surface sight, so their attacks may be discovered too late to save the plants.

Bats have been photographed about agave flowers at night (fig. 2). The bats appear to be after the sweet nectar exuded in the flower tube, and pollen is plainly evident on the head and whiskers, indicating that the bats may be pollinators.

Several species of hummingbirds are frequent about the flowering agaves. During daylight hours, they buzz habitually about the inflorescences, insert their bills in the selected flowers, and perch on the lofty crossarms between forays. Flycatchers use these tall perches, and insects are drawn to the strong-smelling flowers. Doves, flickers, ravens, hawks, caracaras, vultures, and other large birds also use the tall perches. The mutilated flowers, as well as broken branches, appear to be due to bird activities. In Sinaloa, parrots were observed eating agave flowers to such an extent that many spikes had to be examined before undamaged flower speci-

PN–2107

FIGURE 2.—Bat at flowers of *Agave schottii*. (Photo courtesy of George Olin, Naturalist. National Park Service.)

mens could be obtained. The capsules may be carried about by strong birds and the seeds inadvertently widely scattered. Although this has not been observed, missing capsules in inflorescenes have been noted.

Agave flowers attract numerous insects like flies and beetles but chief among these insects are *Hymenoptera*—the honey bees, wild bees, and wasps. In Baja California honey bees were observed to suck dry a massive bloom of *Agave goldmaniana* Trel. during the early morning hours. Bumble bees were also observed visiting the flowers of *A. parviflora flexiflora,* the structure of the flower appearing to be specially modified for the bee's convenience. In the summer of 1963, small, pollen-gathering bees were very active on *A. striata* Zucc. and *A. roezlii* Baker near Tehuacan, Puebla, divesting the anthers of all pollen before dehiscence. Wasps gorge themselves on the sweet nectar. *Hemiptera* of the family Coreidae regularly live with agaves and the pustulate scars dotting the leaves and fruits are apparently due to the probings of these sap-sucking insects. The gardening personnel at Huntington Botanical Garden, San Marino, Calif., reported the loss of many small agaves due to an unprecedented attack by small sap-sucking insects.

Agaves regularly host insects that live as borers in the stems, leaves, and fruits during larval stages. These include butterfiies of the family Megathymidae and moths of the family Prodoxidae. The host-parasite relation is conspecific in some cases. Carpenter bees sometimes nest in the dry agave stalks, making deep borings in the soft pithy tissues. A large snout beetle bores through the stem and leaf base. In Mexico the larvae of one of the Megathymidae is eaten dried and roasted or is powdered and used as a piquant flavoring. In Las Vigas, Veracruz, it was recommended raw as a remedy for rheumatism, and my faithful assistant, Juan Arguelles, who was suffering from sciatica at the time, valiantly ate one, fresh and squirming, from a big maguey. Buprestids and click beetles observed about agave plants may be predacious upon the larval borers.

The fungi *Diplodia theobromae* and *Colletotrichum agavae* may cause serious damage to agave leaves, for they have been reported injurious to the fiber plantations in El Salvador. The climate of El Salvador is relatively moist for fiber culture and probably explains why fungal diseases are not serious in drier regions where agave plantations are generally found. On the whole, agaves are remarkably free of plant diseases.

In summary, agaves operate with other elements of the vegetation to support a wide variety of animal life. The bats, hummingbirds, and some of the insects may serve as pollinators. In some

of the nonselfing agave species, this could be critical for their survival. Conversely, the loss of agaves in some areas where they form a dominant part of the vegetation could result in a decrease of the animal life. We need to know much more about the biotic relationships. For instance, the connection between bats and flowers may be a real mutualism and of evolutionary significance. However, whether this is of benefit to either organism, we cannot positively say. The sweet nectar might cause injurious dental caries in the bats, or the cross-pollinations might genetically "swamp out" a superiorly adapted variant among the agaves. We can only assume that this mutualism may be of benefit to the participants because they coexist in a functional relationship. The agave fauna will appear to him who will sit quietly under a bush and watch.

USES OF AGAVE AND YUCCA

Agave

Agaves have many uses. The fibers of sisal and henequen are worldwide in commerce, whereas fibers of other species have more limited uses. The coarse fibers of *Agave lecheguilla* Torr. and relatives are used for brushes. Many of the Sonoran agave fibers have local uses in twine, rope, mats, saddle pads, packing, brushes, and sacking. In preColumbian times, the Amerindians used fibers in skirts and ornamental dress but these fibers are too coarse and harsh to compete with cotton and modern fabrics for clothing.

Agaves still serve as food plants to many country peoples, including some in Sonora. One of my earliest experiences in the local country cuisine was chewing on chunks of pit-baked agaves prepared by the Mayo Indians along the Rio Cedros in 1933. The white central tissue in the short stems or "cabezas" is still eaten as are the young tender inflorescence shoots, and many an agave maturation is thwarted by cutting off the flowering shoot. Many people believe that this decapitation also improves the sweetness in the cabeza because the rosette goes on living for another year or more. The starchy tissues contained in these cabezas are converted to sugars by cooking. The cooked tissue tastes like strong molasses, frequently with a harsh, after-swallow feeling in the throat. It may act as a purgative on those unaccustomed to this food, to the amusement of the natives. Chewing frees the juice from the fibers, which ball up in the mouth and are spit out, forming the "quids" of archeology. The sugar in agaves and some other members of the family was an important source of energy to the

Indian peoples. However, not all species are edible and some of the species reported as edible in publications are mistaken identities; for example, *A. schottii* was reported as eaten by the Tarahumara Indians in an area where the plant is not known to occur (*38*).

In northeastern Mexico, agave leaves are fed to livestock. In San Luis Potosí in 1963, I observed *A. salmiana* Otto ex Salm. being carted daily to the dairy herds supplying milk to that city. The fresh green leaves amounted to several thousand tons annually. Along with opuntia pads, agave constitutes an important animal food resource in that desert region.

Several of the Sonoran agaves are high in sapogenin content and are used in washing clothes, animal hides, and hair. The basal part of the leaf of *A. vilmoriniana* is used as a readymade cleansing brush, with a built-in soap, the water working into a bubbly froth as the fibers are brushed upon the object being cleaned. Some of the sapogenins, such as hecogenin and smilogenin, are used in medicine as precursors for fabricating cortisone and the sex hormones. The British and others are using hecogenin in pharmaceuticals as a by-product recovered from waste in sisal and henequen operations in Africa and Asia. The U.S. Department of Agriculture in cooperation with the U.S. Department of Health, Education, and Welfare conducted a survey for sapogenins between 1948 and 1956 (*9*) and the analytic results were published (*52–56*). The analyses for the Sonoran Agavaceae are indicated briefly below in the annotations for the respective species.

The Department of Health, Education, and Welfare is presently (1971) conducting a survey for cancer-inhibiting constituents in plants. Several agaves have inhibitive effects on pathological tissues, but the constituents have not been chemically identified and the enquiry is in preliminary stages.

Such chemicals, some of which are already launched in industrial commerce, represent potential plant resources. It has been estimated that the steroids in *A. vilmoriniana* would yield a gross value of $6,000 to $7,000 per acre, with smilagenin at $10 per pound (*22*). However, the development of smilagenin in the leaves of the plant requires a full growth cycle of 7 or 8 years. The green leaves of growing plants assayed only 1 percent or less of smilagenin, whereas the leaves on matured drying plants after flowering assayed 3 to 4.5 percent. The Warihio Indians knew this before we knew it and employed only the old dry leaves as soap. Such prospects are long-term propositions such as tree farms, which require large capital outlay. They naturally exclude the adventurous small businessman who would pioneer on a short-

term basis, and big business is inherently too conservative to pioneer. Such situations should merit government attention, but our legislatures annually have many graver issues demanding their attentions. Political or other conditions, however, could abruptly change the steroid resource situation; for instance, a shortage of diosgenin from the wild *Dioscorea* plants, which currently supply about 80 percent of our steroid imports. Agaves may eventually be developed as a pharmaceutical resource, but none of the native Sonoran species are presently (1971) so employed.

The Indians have reported agave leaves to be used as poultices for itches, sores, bruises, and wounds. Pennington reported that several agaves are used by the Tarahumara Indians as fish poisons (*38*). In addition to sapogenins, the leaves have been reported to contain sterols, terpines, and vitamins (*10, 53*). The leaf chemistry is complex and we know little about it.

There are many local special uses of agaves. I have observed the dried flowering shafts used in fences and as props under fruiting branches in orchards. A modern innovation is the use of agaves in Arizona as Christmas trees. In the United States their greatest use is in ornamental plant culture and they are important as food, shelter, and roosts to wildlife.

Castetter, Bell, and Grove presented an ethnic monograph of agave uses in the Southwestern United States (*8*). They summarize American Indian uses: "In the Southwest, agave was used for a considerable variety of purposes: food, alcoholic and nonalcoholic beverages, syrup, fiber, cordage, nets, bags, basketry, mats, blankets, clothing (particularly aprons), sandals, pottery rests, headrings, braids and other miscellaneous woven objects, hair brushes, paint brushes, needle and thread, fish stringers, armor, lances, fire hearths, musical instruments, paint, a gum-like caulking material, soap, for smoking, medicine, and ceremonial objects. Of these uses, food and fiber were most important and most widespread."

The Aztec codices (*17*) and living Mexican peoples illustrate numerous other basic and exotic uses of these singular American plants. Many of the uses were never developed in Sonora, such as drinking the sweet juice of the maguey agaves, either as "agua miel" or as "pulque" made by fermenting this juice. The distilled liquors of mescal and tequila did not appear until Hispanic occupation, for the Amerindian did not have distillation in his culture. The Sonoran Indians, however, drank the fermented juices of cooked agaves in ceremonies and cures. Those desiring more information on the uses of agaves would do well to consult the information retreaval compendium prepared by Ida Langman (*31*).

Yucca

Yuccas were also important, useful plants to the native peoples from the earliest times, as represented by archeological remains found in prehistoric dwelling sites. As with agave, the strong fibers of yucca were used for clothing and for cordage. The leaves were used more in basketry and continue to be so used. The stems were used in constructions for shelter. The young flowering shoots, fruits, flowers, and inner stem tissues were used as food. The seeds are oily but also contain sapogenin, and I find no reference to them as food. In Sonora the sweet ripe fruits of the fleshy-fruited species are still gathered and eaten either raw or roasted. Cruse (*10*) reported fructose, fructosans, dilevans, and glucose present in several yuccas. Wolf (*60*) found that the dried fruits of *Yucca brevifolia* Engelm. compared favorably in food value with that of dried orange peel.

Yucca flowers have long been eaten by the peoples indigenous to yucca regions. The flowers are generally cooked by boiling and eaten as a vegetable, or combined with other foods such as scrambled eggs. Miller and Hamilton (*37*) reported yucca flowers (probably *Y. elephantipes* Regel) to be rich in ascorbic acid (vitamin C) as follows:

Plant part	Ascorbic acid *Mg./g.*	Moisture %
Raw bud	474.8	82.4
Raw flower	371.3	85.4
Cooked bud	489.7	81.0
Cooked flower	360.0	84.2

In the more sapogenous species *Y. arizonica* and *Y. grandiflora,* only the petals may be eaten, consumer informants having stated that the gynaecium was too bitter. By the use of such wild foods, the Amerindian could obtain his dietary necessities.

The indigenous uses of yucca have been thoroughly reported by Bell and Castetter (*3*), who stated that "yucca ranked foremost among the wild plants utilized by the inhabitants of the Southwest. It holds this place because of the great varieties of uses to which it could be put and to the wide accessibility of the genus within the Southwest."

More modern uses of the yuccas include *Y. glauca Nutt.* and *Y. elata* as livestock feed. In times of range feed scarcity, the stems are defoliated and chopped up for silage (*57*). Cruse (*10*) reported the chemical composition of such material on a dry-weight basis as 4.4 percent protein, 6.7 percent ash, 1.5 percent fat, 3.2

percent fiber, and 49.2 percent carbohydrates. Other chemical assays show the leaves to contain up to 2 percent sapogenins, useful in the manufacture of steroid pharmaceuticals and also as bases for soaps and cleansing powders like dental powders and pastes. The U.S. Department of Agriculture found green fruits and seeds of some species to contain up to 10 percent sapogenins. The highest percentage was found in *Y. brevifolia* and *Y. grandiflora*. Samples of seeds of several species analyzed contained 17 to 32 percent oil and 12 to 22 percent protein.[2]

During World War II, the U.S. Department of the Navy set up a pilot decorticating plant near Kingman, Ariz., for extracting the fibers of *Y. baccata* and *Y. schidigera* Roez. Postwar trials by private interests who took over the plant pretty well showed that exploitation of the wild yucca stands could not compete economically with other sources of commercial cordage, although the fibers were found suitable for rope, twine, and burlap. Because of the splintering effect due to shorter fiber cells, the fibers of yuccas are generally inferior to those of agaves. Weber reports (*57*) that juice from yucca leaves may be more valuable than its fibers. The juice reduces the surface tension of irrigation water (thus increasing its penetration in heavy soils), assists in soil flocculation, and serves as "a carrying agent for the plant food chemicals." Many other chemicals found in yuccas have been reported for a variety of potential uses. However, it is unlikely that any of these potentials will develop in the United States until such time as yucca is put into commercial plantings because the dispersed nature of the wild stands over difficult topography makes their collection uneconomical. The commercial cutting of the tree yucca, *Y. filifera* Chab., as a source of paper pulp in Central Mexico is a notable exception. The scarcity of a natural paper resource in that country and the relatively weak competitive position of the peso have favored the development of a local industry. *Y. filifera* requires a century or more to grow, so it is unlikely that this enterprise will continue any longer than it will take to cut the existing wild stands convenient to roadways.

In the United States, yuccas are valued principally for their ornamental and wildlife attractions. Many of them are being preserved in several public parks, such as the Joshua Tree National Monument and Borego State Park, both in arid California. Yuccas

---

[2] WOLF, IVAN, and others. U.S. Dept. Agr. Rpts. Unpublished and interdepartmental, Northern Utilization Research and Development Division, Agr. Res. Serv., Peoria, Ill. 1960–65.

are increasingly used for landscaping private homes and public grounds, particularly where water is scarce.

HISTORICAL NOTES ON AUTHORS AND COLLECTORS OF AGAVACEAE IN SONORA

During the 19th century three agaves were reported from Sonora: *Agave parviflora, A. schottii* (as *A. geminiflora sonorae* Torr.) in 1859, and *A. schlechtendalii* Jacobi in 1864. Jacobi (*25*) observed *A. schlechtendalii* in several north European gardens and gave its origin as the Province of Sonora, Mexico. I have not been able to recognize the plant from either Jacobi's descriptions or Berger's later one, all drawn from immature specimens. Berger placed it in the section Americanae.

In 1920 Trelease added *A. subsimplex* and *A. yaquiana,* the latter "from rocky hillsides between Hermosillo and Ures, Trelease 391," which I am merging with his *A. pacifica* from Mazatlan. In 1924 I. M. Johnston described *A. owenii,* = *A. pacifica* Trel., from "an islet in Guaymas Harbor, Sonora," and *A. chrysoglossa* from San Pedro Nolasco Island off the Sonoran coast (*29*). In 1942 Gentry added five species, one of which is synonymized here, and brought the total known agaves in Sonora to 10 species (*13*).

In 1964 Shreve and Wiggins ascribed 10 species to Sonora (*42*). Two of these, *A. hartmanii* S. Wats. and *A. mescal* Koch, are here excluded as *nomen confusum* and *nomen nudum,* respectively, as discussed below under *A. polianthiflora* and *A. bovicornuta.* Wiggins prefaced his taxonomic treatment with the following interesting commentary. "The treatment of the genus is dishearteningly inadequate. The range of variation within a species is often extremely puzzling, and it is probable that hybridization occurs frequently. These conditions make a satisfactory taxonomic solution exceedingly difficult. A reasonably acceptable classification of the genus *Agave* can be presented only after extensive and painstaking study in the field, prosecuted at all seasons of the year. The keys and recognition of species here are strictly tentative."

The present treatment describes 27 species, 9 of which are new, and 2 new subspecies. It seems unlikely that more wild species will be added, although some of the coastal postinsular mountains may hold some surprises. Trinomials are increasing in modern taxonomy, so we can expect more of these as our knowledge of relationships grows.

The botanical collection of Sonoran agaves can be briefly outlined, as based upon the herbarium and botanical garden specimens reviewed, as follows:

Year	Collector	Specimens *Number*
1855	Arthur Schott	2
1890	Edward Palmer	2
1899	E. A. Goldman	1
1899	E. W. Nelson	1
1900	William Trelease	1
1910	Rose, Standley & Russell	5
1921	I. M. Johnston	4
1923-	Forest Shreve	4
1932-48	Ira L. Wiggins	4
1937-67	H. S. Gentry	110
1938-40	Steven White	4
1941	Wiggins & Rollins	1
1951-67	Gentry & Arguelles	40
1958-67	Richard S. Felger	34
1966-	Gentry & Weber	5
1966-	Barclay & Arguelles	5

It might appear that more than 200 specimens of about 30 taxa of agave in Sonora would provide a fair sample for taxonomic revision. This is not the case. Many of the collections are fragmentary, consisting only of pieces of leaves or of capsules. Many of my collection numbers are represented only by live plants sent to botanic gardens, with the expectation of obtaining flowering specimens in later years. As a result of neglect, loss of labels, lack of a botanist at hand for collecting at the time of flowering, and depredations by rodents, over half of such collections have been lost. Only three species are represented by a series of flowering specimens: *Agave pacifica* with 10, *A. palmeri* with 9, and *A. shrevei* with 6. Most of the others are represented by 1 to 3 flowering specimens; for one, flowers are unknown. Generally, the rarity of flowering specimens is due to their highland inaccessibility, the rarity and briefness of their flowering seasons, and the reluctance of botanists to spend the time and effort necessary to collect the spiney, wounding, and hard-to-dry succulent plants. The late Susan Delano McKelvey left a note in the herbarium at the Arnold Arboretum on collecting *A. chrysantha* Peebles near Sedona, Ariz. "Reduced to crutches (all way back east) after running a terminal spine of this plant into my ankle; never retrieved by Dr." Some spines appear to carry a toxin for they cause swelling and pain beyond what a mere puncture would produce.

Collections of other genera in the Agavaceae are even scarcer than those of *Agave*. The specimens reviewed and cited for Sonora in this work total only 52, as follows: *Yucca* 25, *Nolina* 10, *Dasylirion* 8, *Manfreda* 5, *Hesperaloe* 4. These specimens are all I found

in the following herbaria: U.S. National Arboretum, Smithsonian Institution, Arnold Arboretum and Gray at Harvard University, University of Arizona, and Gentry. Doubtless a few other specimens exist in herbaria I did not review. Altogether, the specimens are insufficient for an adequate account of the family in Sonora.

Our knowledge of Sonoran plants is primarily due to three works: The vegetation and floristic treatises of Shreve and Wiggins, which cover the desertic region of the northwestern part of the state (*42*); Stephen White's account of the flora on the mountainous area comprised by the Loop of the Rio Bavispe in the northeastern part (*58*); and Gentry's survey of the Rio Mayo basin in the tropical southeastern part (*13*). Most of the specimens cited here (agaves excepted) were part of the general floristic sampling on these projects and on the unpublished work of Richard Felger. There is still a great deal to be discovered about the plants of Sonora, even unknown plants. It is a rich field for botanical research for anyone who has the capacity to engage it.

The writer is grateful to the many people who have helped him in so many ways in his study of the agaves. The Sonoran people are first among these because from the beginning, they were always ready to give information about the stands of wild plants, the trails and roads for reaching them, the names of plants, and their uses. These people included businessmen, ranchers, miners, and the specialists in making "mescal," the "mescaleros." Sonora has an obscure maze of side roads and trails. Where routes are too long or complex to follow by directions, local people will frequently serve as guides. Many will refuse pay, but tips or gifts are acceptable, particularly to children. The native Sonoran people are among the most polite and hospitable in the world and can contribute to any receptive traveler's education. The Sonoran character is epitomized in Juan Arguelles of San Bernardo, my assistant for many years, who accompanied me on my agave forays.

Among the institutions that made their collections and facilities available are: The Huntington Botanical Garden, San Marino, Calif.; Desert Botanical Garden, near Phoenix, Ariz.; and the Herbarium of the Botany Department and the Ecology Herbarium of the Zoology Department of the University of Arizona. The loan of Agavaceae collections of Richard S. Felger of the University of Arizona has been particularly helpful. His collection labels carry the names of several student assistants: R. L. Bezy, Oda Kleine, Joe T. Marshall, Peter Marshall, Becky Moser, Cathy Moser, Alexander Russel, Robert Russel, Dirk D. Stronak, and Robin Thomas.

These were all students of Charles Lowe of the Department of Zoology.

The materials in the Harvard University Herbaria and their extensive botanical libraries were made available. The historical literature there and the agave collections made in Southwestern United States by Susan Delano McKelvey were of paramount value for comparative studies.

The National Herbarium of the Smithsonian Institution in Washington, D.C., has the most complete agave collection in the world and includes the classical specimens made by Alwin Berger at the Hanbury Gardens (La Mórtola) near Ventimiglia, Italy. The Smithsonian collection and my own form the core of evidence accumulated in this work. All type specimens of new species described here are deposited in the Smithsonian Herbarium, along with duplicates of most other numbers I collected.

The drawings of Regina O. Hughes, Plant Science Research Division, ARS (retired), speak eloquently of her careful labor.

I am grateful to Frederick Hermann of the U.S. Forest Service Herbarium in Washington for editing my Latin diagnoses.

SOME CHARACTERS OF AGAVE

Generally, agaves are succulent plants with spirally arranged leaves forming a rosette, some with definite trunks, but more often nearly stemless. Agaves are like annuals in that the rosettes are monocarpic (in Sonora) and flower but once and die. They are like perennials in regard to the time needed to reach flowering maturity. However, perennial as a term does not suit them because perennials flower repeatedly. I have therefore called agaves *multiannuals,* meaning plants that require several to many years to mature and flower once. Many of the palms have this same habit. However, *contingent perennials* may characterize the agaves better because their floral maturation appears to depend not only upon a number of years of growth, but also upon favorable coordination of seasonal temperatures and rainfall. Rosette or growth maturity may be reached several years ahead of floral maturity. This phenomenon is more apparent in more arid environments and reflects the holding capacity of agaves as adaptation to desert conditions.

Ehrler (*11*) has recently discovered that unlike most plants, agave stomates close by day and open by night. This prevents the loss of water through transpiration during hot daylight hours, although it results in a hot leaf surface, hotter than most plants tolerate. Damage to the leaf by high temperature is apparently

prevented by the thick cuticle overlying the epidermis, which is so evident in desert species of agaves. This circadian mechanism and specialized structure are adaptive characters evolved at the environmental edge of life where water is critical. The agave leaf forms a greenhouse over itself, insulated for protection against sun and wind, and translucent to admit the vital light to the photosynthetic cells. The Mixe Indians of Oaxaca use this peelable waxy layer of the agave leaf for wrapping tortilla sandwiches, as we use our modern plastic bags. One may well wonder how this leaf structure came about. The countless gene complexes that were formed were either rejected or accepted by environmental stresses until gradually and finally the genetic combinations balanced and structures were synchronized with the increasing deserts. This is a most interesting area about which little is known, and original research, not only in genetics and evolution but also in ecology and physiology, could find principles applicable to more than agaves. It is out of such particulars that man forms his cogent universals.

The sizes and outlines of the mature rosettes are characteristic and expressive in many agaves. Some radiate the leaves out stiffly, forming an armed hemisphere; others may be urn-shaped or balled by the incurving leaves. The larger leaves sometimes collapse and drop in severe droughts, spoiling the healthy posture. Many species tend to develop a fixed number of leaves, 60 to 80 being median; others may develop as many as 300. However, this number is not fixed because individual conditions or cultivation in foreign sites may delay flowering for years while leaves go on developing. We know little about the factors that finally trigger the maturity of inflorescence, but maturity appears to be a coordinate timing of rainfall and seasonal temperature gradients. Most species are armed with spine-tipped leaves, and many have strong marginal teeth as well.

The relative sizes and shapes of leaves are important. Leaves vary greatly according to age, and their ontogeny is a study in itself. The taxonomist does better to compare and use only the mature leaves. The stiff sword leaf is always the stiff sword leaf (unless it is in shade) and other forms may be just as characteristic of other groups and species. The tendency to be narrowed just above the spreading, clasping leaf base may be fairly constant throughout species populations. This is a helpful character in separating the broad-leaved *A. shrevei* from the related and relatively narrow-leaved *A. palmeri,* because the latter has little or no narrowing below the midblade. Leaves may be thick or thin, hard or soft, according to the species. Basal thickness is correlative with the length and weight of leaf as a structural necessity

for support, so in itself adds little to diagnosing a leaf when the dimensions are given.

The margins of leaves show many characters. On leaves of *A. palmeri* the margins are nearly straight. Other species have leaves with crenate or undulate margins due to the fleshy prominences, *teats,* under the teeth. This crenate character is variably present in *A. shrevei* and *A. bovicornuta,* while it appears always well developed in others, for example, *A. colorata.* A hard, corneous margin may be constantly present in some species, but either present or lacking in others. Frequently, this margin is limited to the apex of the leaf as a deccurency of the spine base. As far as I have observed, the corneous margin is invariably present in the section that takes its name from this structure, the Marginatae, which is not known in Sonora.

Leaf color, though overlaid and lightened by a pruinose or glaucous cuticle, is characteristic in some species, as the dark green of *A. wocomahi,* the yellow of *A. cerulata,* and the light gray of *A. deserti.* In other species leaf color is variable. Light glaucous forms are common in many species and this character can be used safely only in conjunction with other characters. The center pale stripe, which has been used to characterize species, is a form that occurs homologously in many species.

Teeth or marginal prickles occur in many species in both subgenera, but many species in *Littaea* never have them. In subgenus *Agave* they are more nearly universal, although there are a few species in which teeth occur only weakly or sporadically, as in *A. desmettiana* and *A. sisalana* Perrine. In other cases, toothless forms appear in species that are generally well stocked with teeth, as *A. deserti* and *A. parryi* Engelm. Other characters in leaf and flower identify these as merely forms. Teeth have many forms, varying on a single leaf from small towards the leaf base to large in the midblade, flexed upward or downward, curved or straight. There is intraspecific variation, like subtle composition, and it serves to characterize some species; e.g., the down-flexed teeth along the basal half of leaves in *A. asperrima* Jacobi. An unusual and persistent tooth type helps mark some species, as the round tooth form, in cross section, in *A. applanata* Koch and the fish-tailed or biscuspid form in *A. goldmaniana.* Study of teeth variations in populations teaches one how to read them out for species orientation.

Terminal spine forms are less bizarre than teeth but they also vary within species. In some cases it is difficult to determine the specific dimensions of their variability, while in others there is a more recognizable definite tooth form. Spines are sometimes dis-

torted in the bud by the exigencies of early growth and emerge distorted or flexed sharply downward. A still unrecognized species in Puebla has a spine sometimes centrally decurrent down along the ventral keel of the leaf and bearing small teeth, incongruously, along the midleaf line. For self-perpetuation through armor, evolution is producing another innovation.

Some characters, as central leaf stripe, bicuspid or fishtailed teeth, polycarpy, and toothless leaves, appear in unrelated species more or less at random through the genus or even in the genera *Manfreda* and *Furcraea*. Such characters recurring in separate genetic lines are to be regarded as homologous variations and have been discussed by Vavilov and by Darwin as convergent or parallel evolution. This is briefly discussed in "Concept of Species," page 25.

Flower structure has been the most important guide to plant classification since before Linnaeus. Because of the general lack of flowering material, floral morphology has been neglected by agave taxonomists. Berger employed some floral characters in setting up his sections, but the flowers of many species he and others described were like their origins, unknown. My incomplete study of flowers finds them indispensable for an adequate classification and my revision of the genus is still concerned with obtaining flowering specimens of many presumed species.

Agave flowers take many forms although there is a basic likeness throughout their development. The ovary is inferior in all taxa but not quite completely so in what I consider a primitive section, Striatae (not known in Sonora). A definite tube is usually present but is virtually lacking in *A. bracteosa* S. Wats., and *A. guiengola* Gentry (also not known in Sonora). Besides being either deep or shallow, the tube varies in its structural components, in the nectarius inner lining, in ribbing, in form, and its relation with the tepal lobes and filaments. The tepal lobes have been modified in various ways. In the putative primitive form, the six tepals are essentially equal and all alike. More specialized forms develop larger outer tepals, such as those that characterize my section Ditepalae. A 2-ranked perianth has tended to develop with biserial modifications in form and structure, such as in the conspicuous keel on the inner tepal, which is lacking on the outer. The tepals may be open and reflexing or erect to incurved, sometimes involute; some wilt early, others wilt late or not at all. The outer tepals are often hooded and apparently always glandular papillate at the tip in varying degrees or patterns. In some flowers as in the section Marginatae, the tepals fold about and support the long filaments.

The insertion of the filament in the tube is a valuable character on the sectional level. The filament may be inserted in the base of the tube or on the sides of the tube and, at its upper extreme, on the base of the tepals, as in the Deserticolae. In species with a thick glandular or nectariferous tube lining, the base of the filaments grows as out of an inner rim, forming a six-point star shape, as shown by Regina Hughes in figure 22, page 77. Length of filament is variable by growth and not all filaments of the same flower are equal, but in species with exceptionally long or short filaments, the character becomes significant, as with the long stamens of *A. americana* L. Anthers are much alike in gross morphology. Size is generally correlative with flower size, but when this ratio is exceptional, size of the anthers may be of diagnostic value. Anther fixation is always versatile, centric or eccentric, but it appears irregular within species and I find it an unreliable character.

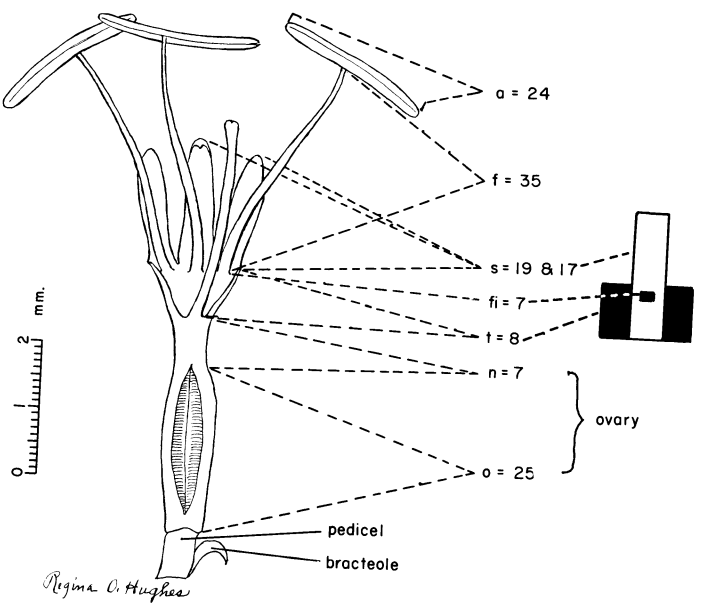
Flower colors range from the common greens and yellows to various shades of purple and red. The strong, dark red found in *A. pelona* is exceptional, as is the nearly white bloom of *A. bracteosa*. Flower color varies within species, with yellow, lavender, and pink forms being found like Mendelian segregates in *A. striata*. The range of variability of flower color or its constancy in populations may be of taxonomic value, but generalized statements of flower color may be misleading. Different flower parts frequently show color differences, as green ovaries and yellow tepals, or yellow perianths with pink filaments. Anthers are commonly yellow, but pinks and reds appear and their color changes with dehiscence.

Capsules and seeds have not been thoroughly studied. The former vary considerably in size and shape in a single inflorescence and cannot be used to separate species, as Trelease used them. There are gross differences in stipitation, beaking, sizes, and ribbings between sections. Seeds also show significant size differences between sections and it is quite probable that microscopic studies would reveal further taxonomic criteria.

The inflorescence shaft with its branches is a massive structure, generally distinct as the spicate form of subgenus *Littaea* and the paniculate form of subgenus *Agave*. However, these two forms are not always just one or the other because there are intermediate forms, as of *A. utahensis* Engelm. and *A. potatorum* Zucc., where the lateral flower umbels may be upon spreading lateral branches or sessile on the shaft. Diagnostic features of value have been noted in the ratio of peduncle length to inflorescence length and the general outline of inflorescence and individual flower clusters,

whether broad, deep, or narrow. The series of bracts generally decrease in size from the base to the tips of the inflorescence in a graduated sequence. On the whole, they express little specific difference, but valuable exceptions do occur, as the fleshy imbricated bracts in the section Salmianae, the short bracteoles of *A. pacifica,* and the long acicular bracteoles of *A. lophantha* Schiede contrasting with the short ones of *A. lecheguilla.*

Flower size varies from the 10-mm.-long flowers found in *A. parviflora* to the over 100-mm.-long flowers in *A. salmiana* Otto ex. Salm. The size ratios between floral organs have been found useful in making diagnostic alinements of sections and species. The diagrammatic drawing in figure 3 shows the various measurements of flower parts. These measurements are useful for analytic comparisons and the floragraph is a kind of taxonomic shorthand based on the ratio of tube and tepal lengths, further qualified by the position of filament insertion.



o - ovary body length, n - neck of ovary length, t - tube length, fi - filament insertion (measured to bottom of t - tube), s - tepal lengths, f - filament length, a - anther length, tl - total length

FIGURE 3.—Long section of agave flower and its floral ideograph derived from the measured parts. The white column represents the tepal, the black part the tube, and the black square the place of insertion of the filament in the tube.

Gross morphology is indeed gross in agaves, because all essential organs are large scale. Variability is expressed profusely and smites the naked eye impressively. I have generally limited my taxonomic criteria to the macroscopic characters rather than belabor the microscopic for the following reasons:

(1) Except for certain floral structures, there appear to be ample characters for classification in gross morphology.

(2) Much of the use of this handbook will probably be made by people who will be looking at living plants, either in the wild or in cultivation.

(3) Brief descriptions of principal characters are better than long, detailed ones when ample illustrations are provided.

It is hoped that users of this handbook will respond to the deficiencies they find because this is also a preliminary trial for a general revision of the genus. Critiques can help to improve the next one to be written.

Other Sonoran genera of the Agavaceae have been included here to orient the genus *Agave* more completely and to make known other obscure Sonoran plants of the family. Like the agaves, the yuccas of Sonora have scarcely been collected. I have known several undescribed species for years. It is time they were formally registered. There is hybridization in both *Yucca* and *Agave,* creating puzzling problems. To unravel them will take more time than this one life; for such a task a man would be fortunate to extend himself by offsets, like an agave. As it is, one will have to let the next botanical generation do it.

The best single taxonomic contrivance for identification of the *Agave* taxa is their separation on a geographic basis. This permits the use of some obvious leaf and rosette characters, which are not serviceable when treating large numbers of taxa in the genus as a whole. There are too many homologous characters in unrelated species or too little leaf difference in some related species to separate them without inflorescence characters. Inflorescence characters are frequently unavailable to those who wish to identify the living wild and cultivated representatives. Hence, whenever possible, for separating taxa, I have used both vegetative and inflorescence characters, supplemented by distribution data.

CONCEPT OF SPECIES

The species in agave are frequently what may be called hard cases. This is partly because many species grade morphologically and variously towards other species and partly because traditional taxonomy has erected many specific names on poorly understood

leaf variation. Jacobi (*24–27*) named many species on the trivial differences exhibited by cultivated plants, many of them immature and growing unnaturally in pots and greenhouses and of unknown origin. Berger (*5*) used floral morphology mainly for his sections, but regarded Jacobi as an authority and conservatively followed close splitting in recognizing species. Baker (*2*), just before Berger, was also unaware of the natural variability of populations in their native states and maintained narrow specific limits. Engelmann was first to evaluate characters in agave and broadened the concept of species, but his studies were brief (*12*). His successor, Trelease, was astute in recognizing differences, and, as though he saw more variability than he could conveniently handle, came to place undue weight in a single character—the terminal spine (*47*). It is very useful for separating clones when growth factors are considered, but agave populations demonstrate that like other organs the spine too can have a wild variability. Trelease, however, was barely acquainted with wild agave populations. Most of the agaves he observed on his Latin American forays were cultivated clones in fields and hedgerows.

The namers of the agaves cultivated in Europe were horticulturists concerned with naming their novelties. The names satisfied their needs for communication, but the practice gave taxonomy a poor start. It set a precedent that conservatism and ignorance follow and that is inadvertently supported by the priority of names. When you name a thing, you have it, in a limited sense, but a label does not always tell what is inside. Every agave is a one-million-year-old package still ticking out genes and, to this practicing taxonomist, they sometimes appear like challenging fiends. Our pages will grow to many before our taxonomic formulas are very truthful.

Evolutionary biology has emphasized that species are composed of populations. This concept is very effective because it leads us to evaluate variability as a collective whole. The reproductions of variability patterns become taxonomic criteria that the systematist can apply to taxa as he judges them on the generic, specific, and subspecific levels. However, if botanists accept zoologist Mayr's (*35*) bological species concept entirely, "groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups," we are soon in trouble. Hybrids are much more common among plants than animals. They occur not only among species but also between genera (*44*). Mayr's phrase "potentially interbreeding" is particularly unsuitable for the definitions of plant species. We do not know what species are potentially crossable, and considering the hundreds of thousands

of plant species, it would take us forever to find them all out. For instance, species are known, that are isolated genetically and geographically, but may be bridged by a third species carrying genes between the isolates. (See Harlan and De Wet compilospecies (*20*).)

If one were to apply Mayr's species definition to the agaves, not only would many species be abandoned, but subgenera would be in danger also (*16*). We might eventually end up with one species, *Agave americana,* which would satisfy nobody with an interest in plants. It is not surprising that animal species are basically different from plant species. There are many different kinds of plant species, as we have come progressively to realize ever since the arrival of Camp and Gilly's article on this subject nearly 30 years ago (*7*). There is no universal model for species, no adequate definition for all plant species; and there are about as many concepts of plant species as there are plant taxonomists.

Species are interfertile groups of individuals composing one to many populations with a recognizable unison of characters. This statement appears to express the working concept I have followed in this enumeration of Sonoran species. Regardless of how species are defined, the practical *purpose of a taxonomic work is to show both close and more distant relationships.*

There are inbreeding and outbreeding agaves and agaves that do not breed at all. There are diploids and polyploids (*18*), and clones that change their karyotypes have been reported (*40*). Variations are phenotypically expressed in cells, organs, habits, and physiologies in baffling sequences throughout the genus.

Homologous variation presents special problems for the taxonomist. Certain characters appear irregularly among species, among genera, and even among families. I have listed some of them above that have been observed in agaves—leaf stripe, bicuspid teeth, toothless leaves, and polycarpy. These characters are misleading for separating species and especially mischievious in keys. The presence or absence is doubtless controlled by genetic factors, but the mechanism is not understood. It appears to be genetic segregation operative on a long-term basis, through hundreds of generations rather than through the few generations that geneticists have documented by experiments with short-term segregating characters. New analytic approaches must be developed to study the geologic-long segregates of homologous variation. The comparisons of distantly related DNA slurries of mice and men, as reported by Hoyer, McCarthy, and Bolton (*23*) demonstrate the compatibility in portions of distantly related chromosomes. Such experiments indicate the great age of some genes,

common origins for higher categories, the great truth of evolution, and the immortality of the generative cell. When our young science of genetics has matured sufficiently to show the causal relationships of homologous variation, we can then orient it more properly with other biological characteristics. At the extremes of the genus, one finds taxa that could be separated generically were the continuum only a bit more broken. Natural breaks occur with distinct species, but more often than not the breaks are expressed by a lack of concordance in the patterns of variation. Study seeks to find the limitation of these variations, which appear as subtle patterns that become familiar with repeated observations and comparisons. To solve these problems, I have sought to study the wild agave populations whenever and wherever the various botanical assignments of the last two decades have allowed me to do so.

In general, the characters of the several major organs require inspection and study to determine the species outline. Taxa may appear very distinct when only one or two individuals are seen, but lose much of their separateness when seen in their variable hundreds. Hybrids are very confusing unless they can be recognized as such. Usually a complex of character variables must be recognized and correlated with distributions and habits. A kind of unison of characters emerges correlative to time and place. Few are those single characters that serve to distinguish a species at a glance, but a few species do have them. Floral morphology is a unifying guide, showing the common relationships of variables; it broadens species and reduces surplus names. However, the flower alone provides no universal frame for every species. Leaf and rosette characters may or may not display significant differences. Frequently it is the breaks in variation patterns of leaves that decide species limits. The supporting evidence in distribution, breeding habits, and biotic relationships provides valuable supplementary evidence to morphology.

My concept of species has been and continues to be an evolving one. My judgments are based primarily upon certain morphological characters that appear to link variable populations or a single population together as hereditary self-perpetuating units. I view species as aggregate lines of descent in the Darwinian philosophy, rather than as discrete typological units in the Linnaean sense. I have drawn some specific lines arbitrarily and tentatively because of insufficient knowledge of inflorescences and respective biologies. Two disjunct populations of sectional alinement that show floral and leaf differences are generally treated as separate species, but unknown intervening populations or future breeding

work might reduce those disjunct populations to subspecific ranks. For example, *A. inaequidens* Koch of the central transverse Mexican ranges and *A. bovicornuta* Gentry of the northern Sierra Madre Occidental are separable by flower and leaf variation pattern differences. Since the former is fall blooming and the latter spring blooming, it seems advisable to treat them as separate species. However, between these two taxa are several related complexes in the mountains of Durango, Nayarit, and Jalisco. Additional specimens and studies are needed for adequate definitions.

I have tried to maintain a fairly narrow interpretation of species because there is a great convenience in the binomial system as compared with the polynomial, which in effect is a retreat to pre-Linnaean taxonomy where descriptive phrases represented the basic taxonomic unit. I am also reluctant to make synonyms out of previous students' species unless I have good evidence to the contrary. I have, therefore, maintained some species that appear doubtful to me, but for which I have insufficient evidence, morphologically or otherwise, to pass judgment.

Trinomials appear indispensable to account for those numerous intergrades that are not clearly one species or the other. Trinomials are inevitable with evolving organisms and usually occupy definite geographic areas in relation to their source species. I call these *subspecies,* distinct from the *varieties,* which in agave are mainly horticultural varieties based on leaf forms. I find no taxonomic merit whatever in the use of subvarieties and subformas because they only burden nomenclature and minds with trivial variations, which are better left as conversational subjects between hobby enthusiasts.

The circumstances controlling my investigations of agaves and their long generative period have prevented the practice of genetic experiments or experimental taxonomy to determine relationships. Our larger herbaria can now provide systematists with sufficient specimens among many genera of plants for detailed studies in species variation and limitations. This is not the case with the Agavaceae because collections have been very few and fragmentary. Most of my specimens for this study were collected from Arizona to Costa Rica. I have attempted to emphasize floral morphology, so basic to plant relationships, because preceding accounts of the genus have neglected it. This has meant repeated trips to distant mountain populations. Relationships not apparent to earlier students are appearing with the growth of the inflorescence collections.

With a feeling of reluctant inadequacy I am attempting to formalize my taxonomic studies in print. There is too much that I

do not know and I hope this essay will not be regarded as authoritarian. The Sonoran agaves are but a small segment of a widespread, large, native American genus. I think my attention was first irremedially called when the late great Paul S. Standley in 1934 refused to identify my first collections of Sonoran agaves; they comprised only two or three specimens of the many hundreds of other plants he identified. Now, like an agave, I am an old being, who must make a show after years of rain and light catching. Among modern men it has become almost mandatory that his genes be given an outing or an inning via the cerebellum. I hope this account will serve to acquaint others with the obscure and interesting Agavaceae in Sonora. Many of them have been markedly depleted by the exploits of man and to be conserved need men to protect them from other men.

AGAVE FLOWER MEASUREMENTS AND THEIR IDEOGRAPHS

Flower Measurements

Measurements of organs and parts have been widely employed in the classification of both plants and animals. Measurements provide basic data for direct and analytical comparisons between species and other taxonomic categories or comparisons of individual specimens. Table 1 gives a nearly complete record of flower measurements made of Sonoran agaves. Figure 3 shows the organs these measurements represent. However, the experience of making these measurements teaches that to be reliably comparable, the measurements must be made in a standardized way subject to certain qualifying conditions imposed by the developing flower. The flowers used should be normal, healthy, and precisely in the stage of anther dehiscence.

TABLE 1.—*Agave flower measurements (in mm.): *, measurements from dried flowers; **, measurements from dried flowers, relaxed by boiling; ***, measurements from fresh or pickled flowers*

Taxon and locality	Ovary and neck	Tube	Tepals	Filament insertion and length	Anther	Total length	Collection No.
Subgenus Littaea							
multifilifera							
Sierra Charuco	16 5	5 X 10	17 X 5	4–5	25 17	43***	8167
	14 5	5 X 10	16 X 5	4–5	32 16	40***	8167
	16 5	5 X 10	17 X 5	4–5	37 17	42***	8167
polianthiflora							
Sierra Charuco	8 1	30 X 5	3	6	35 6	40*	8013
	8 2	30 X 6	3 X 3	4	34 13	40**	8013
	8 1	24 X 5	4 X 4 & 3	4	37 11	37**	8013
	8 1	28 X 5	4 X 4	5	37 12	40**	**8013**
parviflora							
Pajarito Mountains	4 2	5 X 4	2.5	1	9 5.5	13***	17752
	5 2	5.5	2	**1**	**10 5**	**14*****	**17752**
	4.5 2	5	2.5	1	10 5	13***	17752
	4.5 2	5	2	1	-- --	14***	17752
p. flexiflora							
Guasabas	5 1	4	4–5	0	-- --	13**	16638
	5.5 1	4	3.5	0	11 6	14**	16638
Bacadéhuachi	6 3	3–4	4–3.5	0	12 --	17**	16643
	5 2	3–4	4	0	13 6	14**	16643
	5.5 2	4	3.5	0	11 6	14**	16643
Matapé	6 2	3.5	4–5	0	15 5	14***	17744
	6 1	3	4	0	13 5	13***	17744
	5.5 1	3	4.5	0	15 5	14***	17744
schottii							
Pajarito Mountains	8 4	10 X 8	7	6	17 --	30***	17751
	8 4	10	7	6	18 --	29***	17751
	8 2	11 X 7	9 X 5	8–9	18 9	30***	17751
Huntington Bot. Gard.	10 6	10 X 7	11 X 5	8	20 10	36***	19858
	9 5	11 X 8	11 X 6	9	20 11	36***	19858
	8 4	10 X 8	15 X 5.5	10	20 15	36***	s.n.

TABLE 1.—*Agave flower measurements (in mm.): *, measurements from dried flowers; **, measurements from dried flowers, relaxed by boiling; ***, measurements from fresh or pickled flowers*—Continued

Taxon and locality	Ovary and neck		Tube	Tepals	Filament insertion and length		Anther	Total length	Collection No.
Rancho Primavera	8	5	8 X 8	12 X 5	5–6	16	16	32***	21988
	9	4	11 X 8	16 X 5	8	22	17	40***	21988
	10	7	10 X 8	17 X 5	7	25	17	44***	21988
Sierrita Picú	8	5	8 X 7	10 X 4	6	12	11	31***	Noel
	8	5	8 X 6	11 X 4	6–7	16	11	31***	Noel
felgeri									
Bachaca	12	2	3	12	2.5	--	--	30**	11366
	9	3	2	11	1	20	--	25**	17882
	8	4	2	12	1	18	--	25**	17882
	9	2	4	12	2	18	--	26**	17882
Bahia San Carlos	---	--	3	10	2.5	--	--	--	11343
vilmoriniana									
Sierra Charuco	17	3	4 X 8	16 X 4 & 15	4	35	16	40***	10232
	17	3	4 X 8	15 X 5 & 15	4	32	16	39***	10232
Sierra Tecurahui	12	3	3 X 8	17 X 4 & 16	3–3.5	38	15	35***	2016
	14	3	3.5X 8	16 X 4.5	3.5	38	16	37***	2016
	15	4	4 X 8	17 X 4.5	4	40	16	39***	2016
Huntington Bot. Gard.	16	4	4 X 10	15 X 4	4	35	16	40***	19677
	16	4	4 X 10	17 X 4	4	34	16	41***	19677
chrysoglossa									
Bahia San Carlos	13	5	4.5X 9	15 X 6	4–4.5	40	15	37***	19882
	12	5	4 X 9	16 X 6	4	40	15	37***	19882
	13	5	4 X 9	15 X 6	4 & 3	42	15	37***	19882
Bacanora	13	2	4	13	4	25	--	33*	16623
	15	2	4	14	4	26	13	35**	16623
ocahui									
Guasabas	14	1	4	15	4	40	--	35**	16637
	12	2	4	13	4	--	--	31*	16637

pelona									
Cerro Quituni	17	3	9 X 17	18 X 8	9	38	15	47***	19898
	18	3	8	18 X 7	8	20	17	47***	19898
	18	3	8.5	18 X 8	8.5	35	15	46***	19898
Subgenus Agave									
a. expansa									
Amado, Ariz.	33	6	14 X 19	31 X 9 & 29	8–9	68	12 & 16	85***	21983
	32	4	13 X 19	30 X 9	8–9	70	28	80***	21983
bovicornuta									
Sierra Saguaribo	20	2	7 X 12	21 X 4	4–5	40–45	12 & 8	50**	3672
	22	2	8	19 X 4 & 18	3–4	42–45	--	50**	3672
Sierra Tecurahui	29	6	7 X 13	20 X 5 & 19	4–5	45	10 & 14	**62*** **	**2017**
	28	6	6 X 12	19 X 5 & 18	4–5	45	23	58***	2017
Sierra Surotato, Sinaloa	18	4	9 X 14	15 X 6–7	4	30	18	46***	18379
	19	4	8	16	4	34	20	45***	18379
jaiboli									
Sierra de la Ventana	16	3	4 X 8	15 X 4 & 14	3–4	35	13	36**	21177
	24	4	4.5X 8	16 X 4 & 15	3–4	35	13	47**	21177
	24	4	4 X 8	16 X 5	3–4	36	14	47**	21177
desmettiana									
Guasave, Sinaloa	12	1	10 X 14	14 X 5 & 13	6	28–30	15	37***	11569
	11	1	10	14	6	25	15	37***	11569
Brownsville, Tex.	14	1	11 X 14	15 X 5 & 14	7	35	13	41***	18411
	14	1	10	15	7	35	13	40***	18411
murpheyi									
Huntington Bot. Gard.	28	4	17 X 15	18 X 7 & 17	10 & 8	50	11 & 14	68***	-----
	31	4	19 X 19	18 X 7 & 17	11–10	45	12 & 14	71***	-----
	35	4	16	15	10 & 9	--	--	74***	-----
palmeri									
Northwest of Nogales	22	4	13 X 10	12 X 5 & 10	7 & 6	46	17	51***	17750
	26	2	14	12 X 5 & 10	8 & 6	42	17	52**	17750
	28	2	12	10 & 8	6 & 5	40	17	49***	17749
	26	2	12	10 & 8	6 & 5	40	9 & 7	50***	17749

TABLE 1.—*Agave flower measurements (in mm.): *, measurements from dried flowers; **, measurements from dried flowers, relaxed by boiling; ***, measurements from fresh or pickled flowers*—Continued

Taxon and locality	Ovary and neck		Tube	Tepals	Filament insertion and length		Anther	Total length	Collection No.
Sierra Jojoba	23	4	17 X 11	15 X 5 & 13	7–8	46	25	59***	21987
	21	3	15 X 11	12 X 5 & 9	7	42	20	50***	21987
	22	4	16 X 11	15 X 5 & 12	8–9	50	23	55***	21987
	21	5	17 X 11	15 X 5 & 13	8	50	25	58***	21987
	26	5	15 X 13	12 X 6 & 11	7–8	43	21	57***	21987
	31	5	14 X 15	13 X 7 & 11	7–8	43	23	62***	21987
Sierra Baviso	19	3	18 X 12	12 X 6.5	8–9	40	21	52***	21989
	21	3	17 X 12	13 X 6.5	7–8	50	21	53***	21989
wocomahi									
Huicorichi, Chihuahua	27	5	18	13 & 11	11 & 9	55	22	62*	1989
	29	5	17	19 X 5 & 17	11	55	13 & 14	70**	1989
Sierra Charuco	32	3	22 X 15	23 X 5 & 18	13 & 10	62	21 & 12	78***	10252
	36	3	22 X 15	23 X 5 & 21	13 & 10	60	20 & 14	84***	10252
	32	2	22 X 15	22 X 5 & 20	14 & 11	60	21 & 13	78***	10252
Surotato, Sinaloa	28	5	18	15 X 5 & 13	11 & 10	65	25	65**	6340
	29	5	18	14 X 5 & 13	10 & 8	63	26	67**	6340
shrevei									
Sierra Canelo	26	5	23	10 X 6 & 8	14 & 10	50	14 & 8	64**	2028
	25	5	21	10 X 6 & 8	13 & 9	45	13 & 9	62**	2028
Sierra Charuco	26	7	20 X 11	13 X 7 & 11	12 & 10	58	26	65***	8080
	27	5	19 X 11	13 X 7 & 11	11 & 9	55	25	64***	8080
Guajaráy Scarp	25	5	19 X 12	11 X 7 & 10	9 & 8	50	16 & 11	61***	11582
	25	5	20 X 12	12 X 7 & 10	10 & 9	40	16 & 11	62***	11582
Sierra Potrero	32	4	18	12 X 5 & 10	10 & 8	50	14 & 9	66*	11378
	32	5	18	11	10 & 8	50	16	65*	11378
Sierra Saguaribo	26	7	21 X 12	13 X 7 & 11	10 & 8	40	15 & 12	67***	11633
	30	7	22 X 12	12 X 7 & 11	11 & 9	40	--	71***	11633

s. matapensis									
Matapé	20	2	15 X 11	12 X 7 & 10	9 & 8	36	11 & 9	59***	16600
	20	3	16 X 11	11 X 7 & 9	10 & 8	45	20	51***	16600
	20	2	15 X 11	11 X 7 & 10	10 & 8	43	20	48***	16600
	39	2	20 X 14	16 X 7 & 14	10 & 8	52	30	77***	11607
	38	2	20 X 14	15 X 7 & 13	10 & 9	56	28	75***	11607
	31	3	19 X 14	16 X 7 & 14	10 & 7	55	28	68***	11607
colorata									
Aquibiquichi	24	5	16 X 14	16 X 5 & 14	8 & 6	48	26	61**	10270
	18	4	16 X 14	17 X 5 & 15	9 & 7	42	16 & 10	54**	10270
Sierra Bojihuacame	23	4	13 X 14	13 X 7 & 11	6 & 4	50	22	51***	11641
	22	4	15 X 14	12 X 7 & 9	7 & 5	53	21	52***	11641
	24	3	15 X 14	12 X 7 & 10	7 & 5	54	21	53***	11641
huachucensis									
Mount Huachuca	35	9	8 X 16	26 X 6 & 24	5–7	45	27	78***	22580
	37	10	9 X 17	27 X 5 & 25	7–8	58	27	81***	22580
Sonoita	31	6	8 X 14	22 X 5 & 21	7–6	52	24	68***	22581
	35	6	8 X 15	23 X 5 & 22	7	58	25	71***	22581
	33	8	9 X 14	19 X 5 & 17	7	50	20	68***	22582
	33	7	8 X 14	19 X 4 & 17	7	50	20	66***	22582
fortiflora									
Sierra Jojoba	34	11	11 X 18	20 X 7 & 19	8 & 6	60	20	75***	11630
	31	11	11 X 18	20 X 7 & 18	7 & 5	58	20	72***	11630
	33	12	12 X 18	19 X 7 & 18	8 & 6	60	20	75***	11630
zebra									
Sierra Viejo	25	5	6 X 10	14 X 5.5 & 13	3	35	17	50***	21984
	21	4	5 X 10	11 X 5.5	3	30	12	40***	21984
	20	4	6 X 13	14 X 5 & 13	4	35	16	43***	21984
	28	4	6 X 12	15 X 5 & 14	3–4	38	18	53***	21984
subsimplex									
Puerto Libertad	19	5	4 X 9	11 X 4	2–3	24	9	40*	4486
	20	5	4 X 10	13 X 6	3	20	13	41**	4486
	--	5	3 X 10	12 X 5	3	20	13	**	4486

TABLE 1.—*Agave flower measurements (in mm.): *, measurements from dried flowers; **, measurements from dried flowers, relaxed by boiling; ***, measurements from fresh or pickled flowers*—Continued

Taxon and locality	Ovary and neck	Tube	Tepals	Filament insertion and length		Anther	Total length	Collection No.
deserti								
San Felipe, Calif.	18 5	4 X 15	14 X 6	5	31	13	40***	19741
	18 4	4 X 15	14 X 6	5	31	13	40***	19741
	16 5	4 X 15	13 X 6	5	30	13	38***	19741
	21 6	5 X 15	16 X 8	5.5	23	15	47***	19940
	20 6	5 X 15	16 X 8	6	28	15	48***	19940
	21 6	5 X 15	16 X 8	6	26	14	53***	19940
fourcroydes								
Mórtola (Berger)	30 5	16 X 15	17 X 3	8	55	20	66*	6/8/09
	30 6	15 X 15	17	--	60	--	70*	6/8/09
pacifica								
Felis Gomez	20 2	6 X 12	20 X 4	5–3	45	20	48***	19885
	22 1	7 X 12	19 X 4	4	45	20	49***	19885
	25 1	8 X 12	18 X 4	4–5	45	--	52***	19885
Navojoa	27 3	11 X 14	19 X 5 & 18	5–6	40	13 & 11	61***	19875
	23 4	10 X 14	18 X 5	5–6	40	13 & 10	56***	19875
	24 4	9 X 10	18 X 4	5–6	38	21	54***	19875
Sierra Tecurahui	21 4	11 X 10	19 X 3	6	35	14 & 10	57***	19359
	21 4	12 X 10	20 X 4 & 18	6	35	24	58***	19359
	22 4	11 X 10	20	6	45	14 & 10	57***	19359
	25 3	14 X 13	24 X 5 & 22	10	45	17 & 13	67***	19368
	25 3	15 X 13	24 X 5	10	45	16 & 13	67***	19368
	26 3	14 X 13	25 X 5	10	46	16 & 14	68***	19368

Sonora-Sinaloa border	17	3	9 X 11	22 X 4	5–6	37	16 & 12	52***	19656
	19	1	9 X 10	22 X 4	5	42	16 & 12	52***	19656
	20	2	8 X 10	24 X 4	5	40	16 & 12	51***	19656
	25	5	13 X 10	18 X 4	10	40	13 & 11	61***	19655
Cerros del Fuerte	25	4	11 X 10	22 X 4 & 20	8	42	15 & 10	63***	19655
	27	6	14 X 10	18 X 4	10	50	13 & 13	65***	19655
rhodacantha									
Mazatan, Nayarit	20	5	10 X 9	16 X 4	6–7	40	8 & 5	54**	10783
	25	4	9 X 9	16 X 4	--	33	--	54**	10783
	26	2	8 X 10	22 X 4	5	46	22	56*	10704
	28	3	8 X 10	23 X 4	6	44	28	62*	10806

The flower bud grows slowly but opens and expands very rapidly during anthesis (expansion of the flower) within 1 day. Therefore, measurements for comparative purposes must be taken at about the time of anther dehiscence, which occurs during a few daylight hours. However, flowering begins at the base of the inflorescence and continues to move upwards in the inflorescence for 2 to 4 weeks, depending upon individual plants and species. One can usually find a series of flowers in late bud stage, at anther dehiscence, and after dehiscence, all in one flower cluster. I prefer to have measurements of flowers just before, during, and right after stamen dehiscence so maturation is bracketed. For this purpose, I collect and immerse the flowers in a pickling solution of 1 part formaldehyde, 3 parts 95 percent alcohol, and 6 parts water. Pint-size canning jars in cartons of one dozen are suitable for field work and accommodate all except a few of the very largest flowers. For permanent storage, they must be transferred to laboratory jars with noncorrosive resinoid tops. Labels are put inside the jars.

The pistil continues to grow after anther dehiscence, usually for 2 or 3 days, when the stigmas open and are receptive. Because of this later growth, measurements of pistils at anther dehiscence have no comparative value and have not been made.

Floral Ideographs

The measurements can be analytically applied to form the symbolic floral ideograph. The various forms of ideographs and their applications were very ably described and applied by the late Edgar Anderson (*1*). The form ideographs may take is more or less determined by the organs, which the taxonomist finds best representative of the variability that expresses speciation, introgression, or developmental features of a related group of organisms. The ideograph here selected shows the tube/tepal ratio, together with the insertion of the filament within or on the rim of the tube and, more rarely, on the base of the tepal. The ideograph is a kind of taxonomic shorthand that throws into perspective the selected characters, so strikingly apparent in figure 4, *A* and *B*.

These floral ideographs are also employed on the maps to show the known distributions of the respective agave species (figs. 13, 24, 31, 39, and 55). The ideographs are reduced in size and still

function as meaningful symbols. Ideographs with a collection number below indicate that the ideograph is based upon a flower collection at that locality. Others without a number are typical or mean species ideographs drawn from the measurements in table 1 or selected from the ideographs shown in figure 4, *B*. The ideographs serve as specific representatives of documented localities.

Old dried flowers are shrunken and distorted by the growing ovary and measurements of them are unreliable. They are little improved by relaxing. Berger at La Mortola Botanical Garden pressed split flowers under great pressure and, so-treated, their proportions remain fairly reliable.

The junction of tube and tepals is a particularly critical level, as the length of both organs derive from this. In measuring the length or depth of tube, one must note the various tepal sinuses because some may be deeper than others in the same flower. The upper limit of tube is taken at the median level of the sinuses. Where there is marked overlap of tepal bases in the sinuses, the median point of the overlap is taken as the upper limit of tube. There is, thus, a built-in indefiniteness about many tubes that may amount to a 1-mm. variance or a margin of about 10-percent inexactness for tube measurement. Also, one must watch for damage by insects and birds, which sometimes split the sinuses. With measurements of three or four flowers, made after splitting the flower lengthwise, these difficulties are largely overcome and the mean or medium measurement is suitable for comparisons with other collections.

Diameter of tube is its widest extent, usually at about the level of filament insertion.

Width of outer tepal is the median width just above the basal widening, or about ⅓ to ½ tepal length above the tepal sinuses. This is bound to be a general-impression kind of measurement as it depends on degree of wilting, or degree of inrolling, and cannot, therefore, always be precise.

Where there is marked difference in length of outer and inner tepals, the length of the outer is given first. Width of the inner tepal is not given, but its form, shape, or other qualifying characteristics are indicated in the description of species.

Where two measurements appear under anther, these indicate the parts on each side of filament attachment. Total anther length is equal to the sum of the two figures. Anther length is given in this way only to indicate the degree of eccentric fixation. Dried anthers swell more than any other organ when boiled in water.

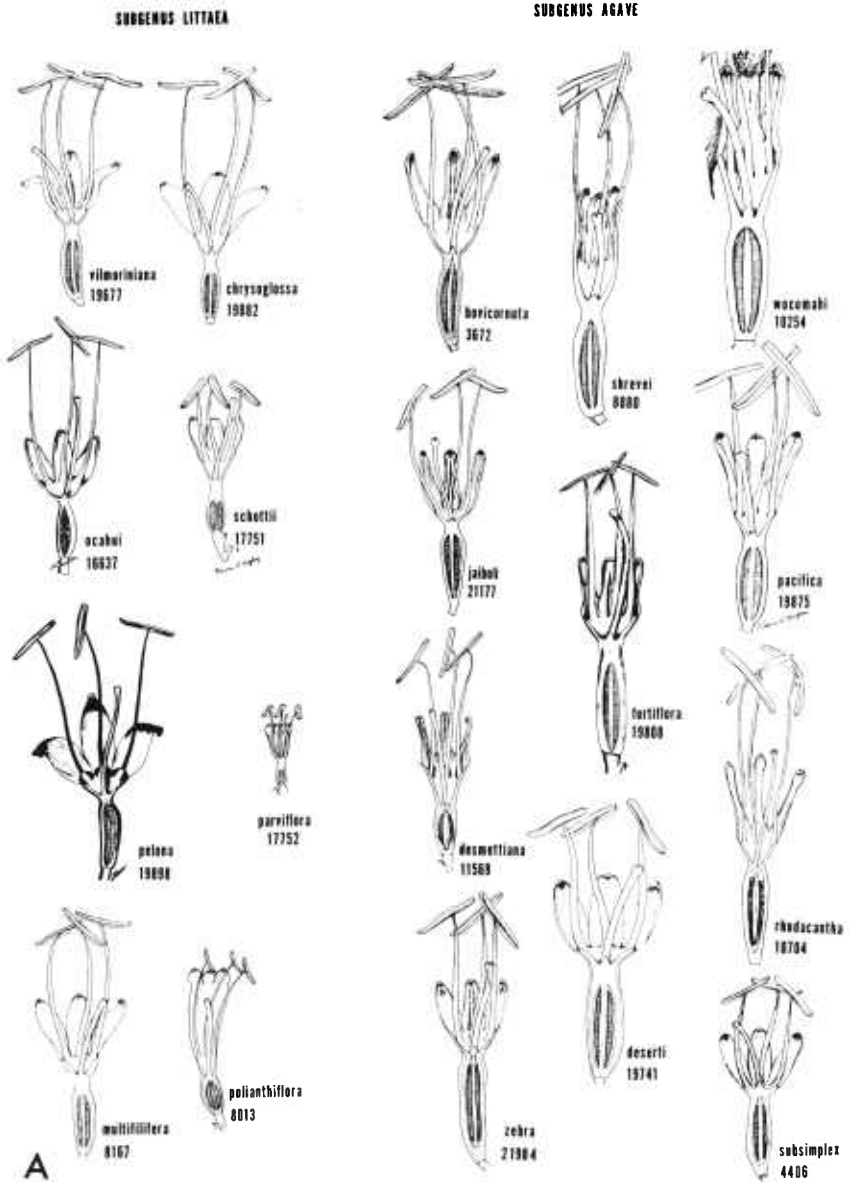
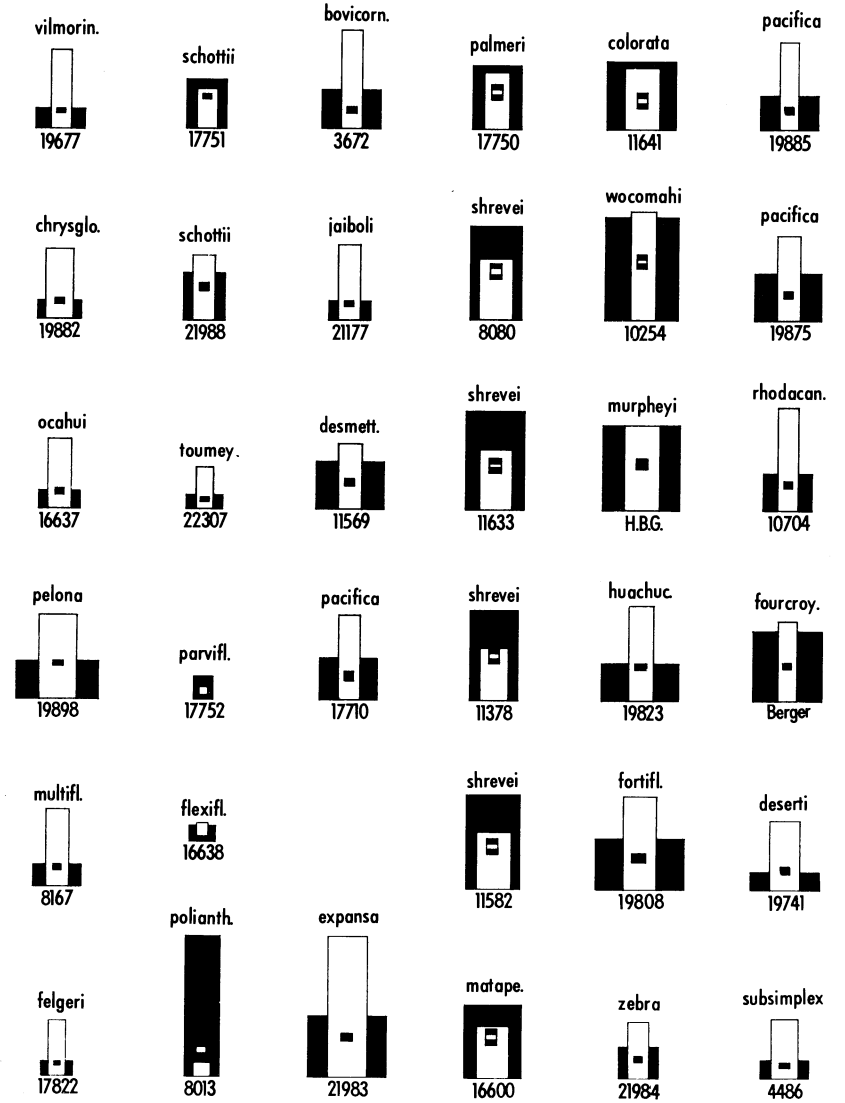


FIGURE 4.—*A*, Long sections of agave flowers showing general floral organization and diversification. Scale is not uniform; *A. parviflora* and *A. deserti* only slightly reduced, others reduced from ½ to ⅔ natural size. The diversity in agave flowers is symbolized in the ideographs on the opposite page (fig. 4, *B*).



B, Ideographs of agave flowers, which depict relative proportions of organs derived by measurements, ratio of tube (black) to outer tepal (white column), and insertion of filament in tube (black square). Measurements are listed in table 1. See also figures 3 and 4, *A*.

ANNOTATION OF SPECIES

Key to Genera of Agavaceae in Sonora

Ovary inferior; perianth segments united to form a tube; anthers exserted or, rarely, included. (Agaveae)

Succulent multiannuals[3] or, rarely, perennials, without fleshy underground stems and succulent roots; leaves enduring for many years, large, succulent, with conspicuous terminal spines; inflorescence a dense spike, raceme, or panicle; anthers exserted ---------- *Agave*

Perennial herbs with fleshy underground stems and succulent roots; leaves enduring only 1 season or short-lived, relatively small, weak, and without terminal spines; inflorescence of lax spikes or racemes; anthers exserted or included.

Filaments exserted; flowers actinomorphic, the tube not ampliate above ---------- *Manfreda*

Filaments included; flowers zygomorphic, the tube ampliate above ---------- *Polianthes*

Ovary superior; perianth segments free or nearly so; anthers included.

Leaves with terminal spine; flowers large (2 cm. wide or more), usually succulent, perfect, campanulate; capsules large, woody; seeds black, usually discoid, numerous in a cell. (Yuccae)

Perianth segments spreading, not connivent, broad, white; filaments pubescent ---------- *Yucca*

Perianth segments narrow, connivent forming a tubelike flower, variously colored; filaments glabrous .... *Hesperaloe*

Leaves without terminal spine; flowers small (less than 1 cm. wide), not succulent, often unisexual, stellate; capsules small, papery; seeds not black, never discoid, only 1–3 in a cell. (Nolineae)

Leaf margins armed with sharp, curved spines; plants completely dioecious; capsules 1-celled, winged; seeds angled; flowers in dense catkinlike spikes ---------- *Dasylirion*

Leaf margins entire or serrulate; plants incompletely dioecious, some flowers perfect; capsules 3-celled, 3-lobed; seeds globose; flowers in diffuse panicles ---------- *Nolina*

---

[3] Multiannuals are plants that flower once and die, but require several to many years to mature.

AGAVE L., SP. PL. 323. 1753.

Succulent rosettes, monocarpic or polycarpic, perennials or multiannuals with long-lived leaves, frequently suckering at base and occasionally bulbiferous in the inflorescence; roots hard fibrous, radiately and shallowly deployed; stems thick, very short, usually shorter than the terminal bud, simple or branched; leaves large, generally succulent, spine-tipped, margin armed or unarmed with teeth; inflorescence tall, bracteate, scapose, spikate, racemose, or paniculate with flowers in umbellate clusters; flowers mostly large, generally proterandrous; perianth tubular to shallowly funnelform, the 6 segments erect to variously curved, similar or dimorphic, imbricate in the bud; stamens 6 exserted; filaments long, inserted in tube or on tepal bases; anthers versatile; ovary inferior, 3-celled, succulent, thick-walled with numerous axile ovules in 2 rows; pistil elongate, filiform, tubular; stigma 3-lobate, papillate glandular; fruit a dehiscent, loculicidal capsule; seeds flattened, black.

Key to Agave Species in Sonora

Inflorescence spicate or racemose ..... Subgenus *Littaea*
Inflorescence paniculate, flowers in umbellate clusters on lateral branches ..... Subgenus *Agave*

Subgenus *Littaea*

1– Leaves filiferous, small or narrow, usually with white bud printing on the surface; flower tube deep, narrow 2
1– Leaves not filiferous, the margins smooth, larger; flower tube very short, the tepals several times longer than the tube (except in *pelona*) 6
2– Rosettes large, (40–60 cm. tall), with numerous leaves (150 or more); leaves 40–50 cm. long; tepals greenish (section Filiferae) ..... *multifilifera*, p. 46.
2– Rosettes small (20–30 cm. tall), with relatively few leaves 40–70); leaves 10–40 cm. long; flowers yellow or pink (section Parviflorae) 3
3– Flowers red or pink, long-tubular, the tube 25–30 mm. long, 7–10 times longer than the segments ..... *polianthiflora*, p. 51.
3– Flowers yellow or yellowish green, the tubes much shorter, 3–10 mm. long, little longer or about equaling the segments 4
4– Flowers very small, 11–15 mm. long; leaves 10–20 cm. long, linear-lanceolate ..... *parviflora*, p. 54.
4– Flowers larger, 25–40 mm. long; leaves 20–40 cm. long, linear 5
5– Flower tube narrow and deep, about equaling or exceeding tepals. Mountain highlands ..... *schottii*, p. 57.
5– Flower tube shallow, open, about ¼ the length of the tepals. Coastal lowlands ..... *felgeri*, p. 60.
6– Leaves large, 1–2 m. long 7
6– Leaves small, 20–40 cm. long 8
7– Leaves deeply guttered, arching, 1.2–2 m. long; inflorescence frequently bulbiferous; tepals linear-lanceolate, 4–6 mm. wide ..... *vilmoriniana*, p. 62.
7– Leaves plane, about 1 m. long, straight; inflorescence not bulbiferous; tepals ovate-lanceolate, the inner 8 mm. wide ..... *chrysoglossa*, p. 69.
8– Leaves rather pliant, green, with fine brown margins; flowers yellowish, short-pedicellate (5–10 mm. long) ..... *ocahui*, p. 72.
8– Leaves rigid, purple-tinged and with conspicuous white margins; flowers red with a large tube, long-pedicellate (15–25 mm. long) ..... *pelona*, p. 76.

Subgenus *Agave*

1– Leaves sword-shaped, 10–25 times longer than wide, mostly 9–20 dm. long, straight, stiff, and always armed with teeth; tepals wilting with anthesis, early drying sharply reflexed; inflorescence frequently bulbiferous (section Ensiformae) ---------- 15

1– Leaves rarely sword-shaped, 3–10 times longer than wide, variously curved, if stiff, then short and broad, sometimes toothless; tepals not normally wilting at anthesis and not drying sharply reflexed; inflorescence rarely bulbiferous except in two species ---------- 2

2– Rosettes large, suckering prolifically; mature leaves 120–170 cm. long, broadly lanceolate; flower umbells diffuse and broadly spreading (section Agavae, 1 cultivar in Sonora) ---------- *americana*, p. 80.

2– Rosettes small to medium, usually suckering sparsely or not at all; mature leaves less than 120 cm. long; flower umbells compact ---------- 3

3– Rosettes not suckering; leaves green to yellowish green, lanceolate to spatulate, frequently with interstitial teeth between prominent teats; panicles usually narrow, elongate, with 25–40 laterals; tepals about twice as long as tube (section Crenatae) ---------- 4

3– Rosettes suckering, soon or late; leaves mostly glaucous gray but sometimes green, linear to broadly lanceolate, if interstitial teeth present then not between prominent teats; panicles less narrow and shorter, with mostly 10–20 laterals (*A. huachucensis* up to 25–30); tepals shorter or much longer than tube ---------- 5

4– Leaves broadly lanceolate to spatulate, about 4 times as long as wide, strongly narrowed above base, margin markedly crenate ---------- *bovicornuta*, p. 85.

4– Leaves narrowly lanceolate, about 6–10 times as long as wide, only slightly narrowed above base, margin merely undulate ---------- *jaiboli*, p. 89.

5– Leaves without teeth or teeth small and irregularly occurring, tender and arching; ovary about ½ as long as perianth; tube with prominent ridges within on each side of filaments; tepals thin (section Sisalanae, 1 cultivar in Sonora). *desmettiana*, p. 94.

5– Leaves usually armed with teeth (some species have toothless forms), generally tough and stiffer than above; ovary and perianth about equal in length; tube without prominent ridges within; tepals thick ---------- 6

6– Rosettes medium size; leaves lanceolate, mostly broadly so and short acuminate, 30–90 cm. long; flowers with a well-developed tube; tepals less than 3 times as long as tube; filaments usually inserted well below orifice of tube ---------- 7

6– Rosettes small; leaves triangular-acuminate, 20–50 cm. long; flowers with short open tube; tepals 3–5 times as long as tube; filaments inserted at orifice or on base of tepals ---- 14

7– Tepals unequal, the outer longer and overlapping the inner, about equaling or shorter than the tube, persistently erect; filaments inserted unequally in midtube, those below outer tepals conspicuously higher (section Ditepalae) ---------- 8

7– Tepals about equal, longer than the tube, not drying erect; filaments inserted about equally in tube ---------- 12

8– Leaves linear or long-lanceolate, 5–10 times longer than wide, widest at or below the middle; margin straight or nearly so; teeth small to medium ---------- 9

8– Leaves ovate to lanceolate, 3–6 times longer than wide, widest at or above the middle; margin undulate or prominently teated under teeth; teeth frequently large and flexuous --- 10

9– Leaves linear; spine conical, short, up to 2 cm. long; flowers about 70 mm. long; inflorescence bulbiferous ---*murpheyi*, p. 99.

9– Leaves lanceolate; spine long acicular, 2.5–6 cm. long; flowers 40–60 mm. long; inflorescence rarely bulbiferous. *palmeri*, p. 101.

10– Rosettes green, medium to large, not suckering; tepals brownish at tips, about equaling tube, sinuses open; panicles large, 5–7 m. tall ---------- *wocomahi*, p. 105.

10– Rosettes glaucous gray, small to medium, suckering at base; tepals red or brownish, usually shorter than the tube, sinuses closed; panicles relatively small or short, usually less than 5 m. tall ---------- 11

11– Leaves uniformly gray; marginal teats lacking or moderate in size; panicles tall, small, open with few laterals in upper ⅓ of shaft; tepals shorter than the deep tube ---*shrevei*, p. 111.

11– Leaves conspicuously cross-zoned and sometimes pink-tinged; teats prominent; panicles deep, relatively dense with many umbells in upper ⅔ of shaft; tepals about equaling the tube ---------- *colorata*, p. 117.

12– Rosettes compact with numerous (80–110), short, stiff, incurving, nearly plane leaves, not cross-zoned, smooth.
huachucensis, p. 119.

12– Rosettes open with few (40–70), ascending or arching, guttered leaves conspicuously cross-zoned and scabrous ____13

13– Leaves straightly ascending, slightly guttered, relatively narrow, 5–8 times longer than wide; margins straight or with small teats; flowers 70–80 mm. long, long-lasting; filaments flattened, 4–5 mm. wide ____*fortiflora*, p. 122.

13– Leaves arching low, spreading, deeply guttered, relatively broad, 3–5 times longer than wide; margins deeply crenate with prominent teats and teeth; flowers about 50 mm. long; filaments slender, oval in cross section, 2 mm. wide.
zebra, p. 126.

14– Plants 20–30 cm. tall; filaments inserted just below base of tepals in orifice of tube; tepals elliptic, broadest at the middle.
subsimplex, p. 131.

14– Plants 30–50 cm. tall; filaments inserted on base of tepals above tube; tepals lanceolate, broadest at the base.
deserti, p. 134.

15– Rosettes developing a trunk 1–2 m. tall; leaves uniform, 8–10 cm. wide; teeth regular, mostly 2–4 cm. apart, small, less than 5 mm. long; panicles sterile (cultivar) __*fourcroydes*, p. 138.

15– Rosettes acaulescent or with a short trunk; leaves and teeth variable; teeth generally longer than above, the larger along midblades over 5 mm. long; panicles bearing seeds; capsules large, ovate to oblong ____16

16– Leaves mostly less than 150 cm. long; teeth proximal or remote; inflorescence 3–5 m. tall with fewer than 25 laterals; capsules 3.5–5 cm. long, short-stipitate (less than 7 mm.) __17

16– Leaves mostly 150–200 cm. long; teeth proximal, strong; inflorescence 7–9 m. tall with 30–45 laterals; capsules 6–8 cm. long, long-stipitate (10–15 mm.) ____*rhodacantha*, p. 141.

17– Stems elongate; leaves variable, mostly 70–150 × 4–7 cm., yellowish green to light green, rarely glaucous; teeth proximal; spine rounded to the base, gradually subulate.
pacifica, p. 143.

17– Stems globose; leaves regular, 40–60 × 2–3 cm. bluish glaucous; teeth remote; spine broad and flattened above at base, abruptly subulate ____*aktites*, p. 148.

Subgenus *Littaea*

***Agave multifilifera* Gentry, sp. nov.** **Figure 5**

Single, monocarpic, nonsurculose, green rosettes, about 1 m. tall; 1.5 m. broad, with a short trunk at maturity and 200 or more leaves; leaves 50–80 × 1.2–3.5 cm., linear-lanceolate, broadest at base, erectly ascending to declined, long-filiferous, plane above, slightly convex below, firm but pliant, smooth, light green, spine 1–1.5 cm. long, subulate, flattened above, castaneous to aging gray; spike to 5 m. tall, 18–21 cm. thick with flowers, densely flowered from level of upright upper leaves; lower flowering bracts about twice as long as flowers, grayish, subulate, the upper bracts much shorter; buds green with lavender luster; flowers pale waxy green with pink tinge on tepals, 40–43 mm. long; ovary 20–21 mm. long with constricted, faintly grooved neck 5 mm. long; tube 5 mm. long, 10 mm. broad at apex, short-funnelform, the nectarious innerliner about filling the tube; tepals 16–17 mm. long, subequal, narrowly elliptic, some erect, some recurving at anthesis, apiculate, the papillate area broad and decurrent on the inner tepals, the outer tepals narrower, 5–5.5 mm. wide, and also with a low keel; filaments 35–40 mm. long, slender, red, elliptic in cross section, anthers yellow, 16–17 mm. long; pistil slender, whitish; capsule 20–25 × 10–12 mm., slender ovate, apiculate; seeds small, 3.5–4.5 × 2.5–3 mm., the curved margin with a wrinkled or erose winglike edge, hilum notch abrupt.

Type—*Gentry 8167*, north rim of Arroyo Hondo, Sierra Charuco, Chihuahua, live plants collected April 1948, flowered at Murrieta, Calif., June 10-July 18, 1966, deposited in U.S. Natl. Herbarium No. 2558493 and No. 2558494. Also at type locality, *Gentry 10247*, March 7, 1951, (live pl.) ; Sierra Guicorichi, Chihuahua, Aug. 25, 1951, *Gentry & Arguelles 11399* (lv. & live pl.) ; 20 km. north of Puente de Basihuare (Rio Urique) along road from Creel to La Bufa, Chihuahua, June 9, 1963, *Felger & Russell 8135* (lvs.), deciduous oaks. Its habitat is the rocky ledges and cliffs in the

Planta singulo brevicaulis; foliis viridibus lineari-lanceolatis, 50–80 cm. longis 1.2–3 cm. latis, supra plana infra convexa, margine longo-griseo-filiferis; spina terminali parva 1 cm. longa, castanea vel grisea; scapo inflorescentia inclusa 5 m. alto, bracteis ad basim inflorescentibus 8–10 cm. longis subulatis; floribus viridis pallidoroseis, 40–43 mm. longis; ovario 20–21 mm. longo ad apicem constricto; tubo 4.5–5 mm. longo 9–10 mm. lato infundibuliformis; segmentis subequalibus 16–17 mm. longis 5–7 mm. latis, anguste elliptis apiculatis; filamentis 35–40 mm. longis roseis ad apicem tubo insertis; antheris luteis, 16–17 mm. longis; capsula parva 20–25 × 10–12 mm., angusti ovata, apiculata; seminibus parvi 3.5–4.5 × 2.5–3 mm.

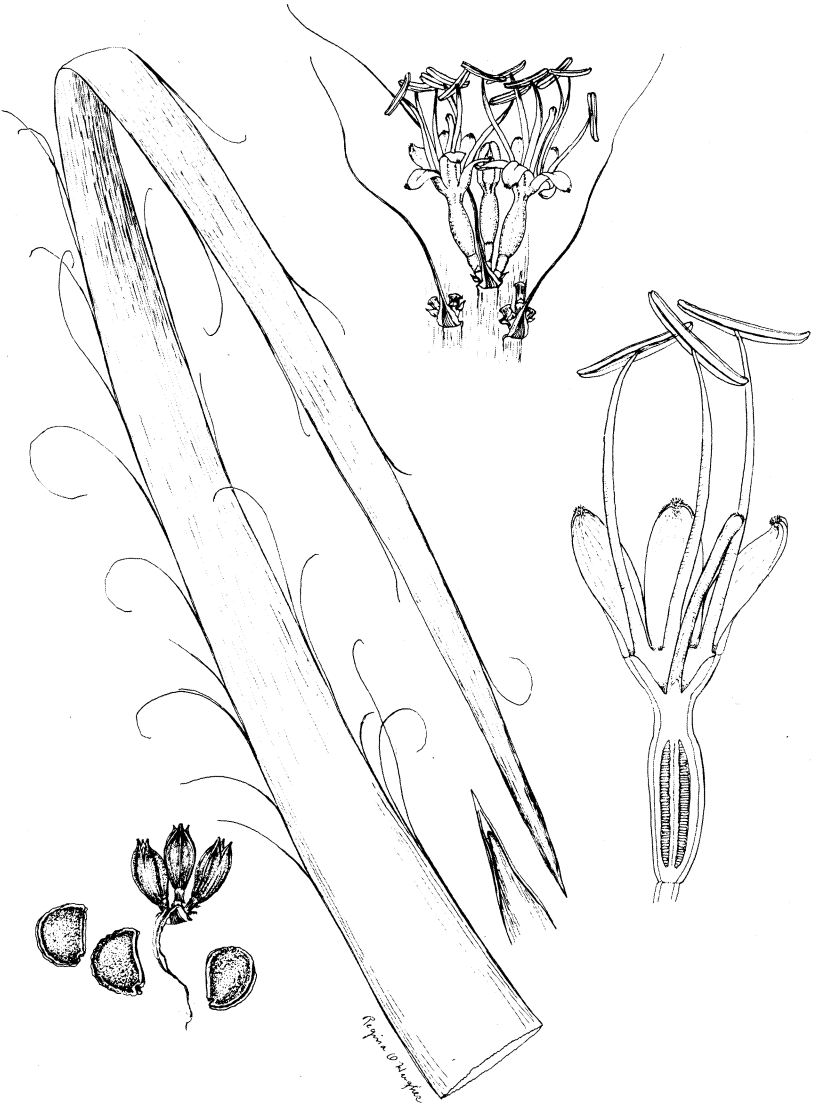


FIGURE 5.—*Agave multifilifera:* Leaf, flower cluster, and capsules less than × ½; flower section and spine tip slightly enlarged; seeds × 2. Drawn from Gentry 8167.

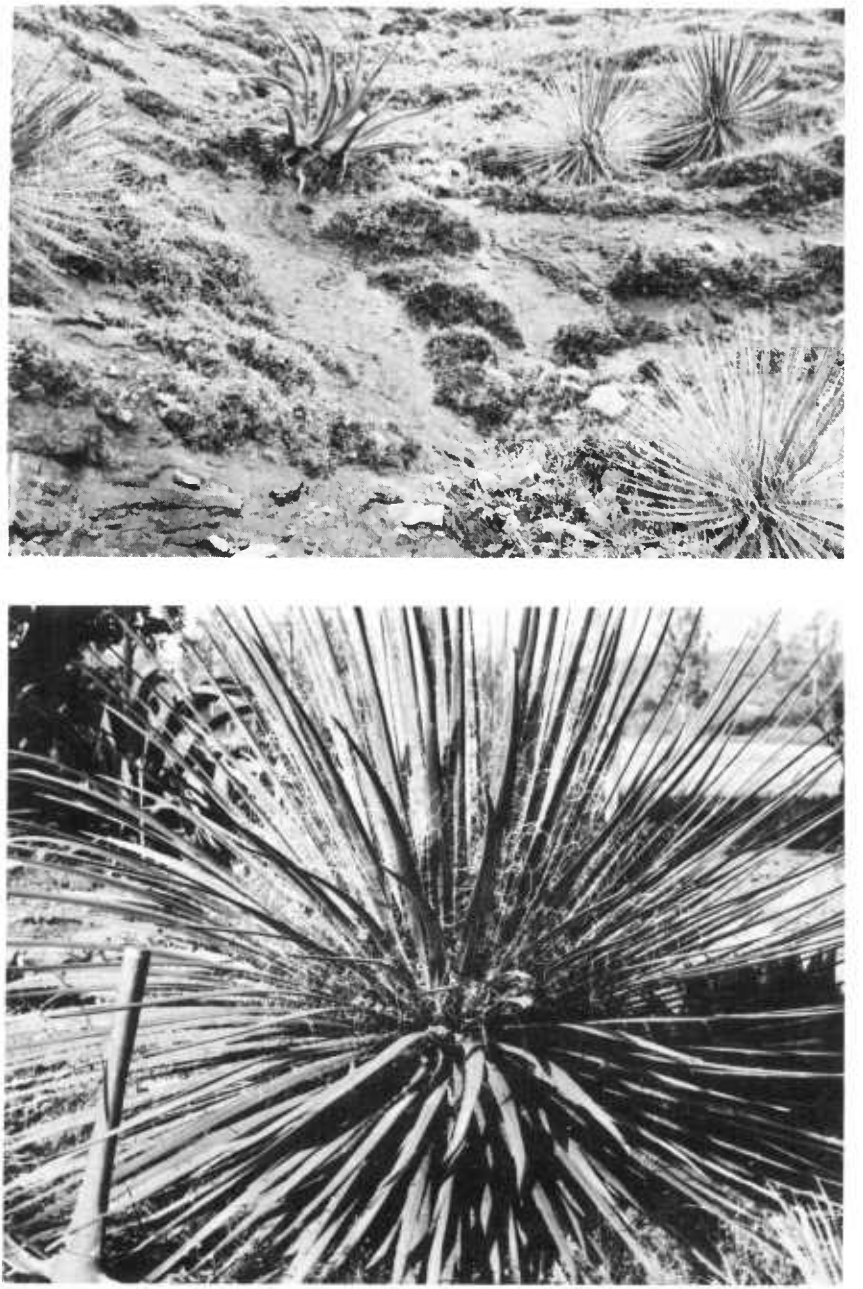
pine and oak forests elevations between 4,500 and 6,500 feet. The species is known only from the northern Sierra Madre, the southern record being live plants in the Jardin Nacional, Mexico, collected in Durango. The photograph in figure 6 shows several plants on brecciated lava in the scattered population on Sierra Charuco, where the soil is too thin to support trees. This is very near the Sonora-Chihuahua border.

The habit, filiferous leaves (fig. 6), and flower form place this species in the section Filiferae, of which it is the largest known member. The stems in cultivation reached about 2 feet in height. Like other species of the Filiferae, the flower has a regular funnelform tube and recurving subequal tepals, and the filaments are inserted on the rim or orifice of the tube. However, the tube of *A. multifilifera* is considerably shorter in reference to the tepals than that of other relatives. The short tube is like that of *A. filifera,* while the thinner flatter, leaves are more like those of *A. schidigera.* Some of the size differences may be compared in the following way:

	Tube	Tepals	Leaves
	Mm.	*Mm.*	
A. multifilifera	5	16-17	Thin, elongate.
A. filifera	5-8	14	Thick, short.
A. schidigera	8-10	13-16	Thin, short.

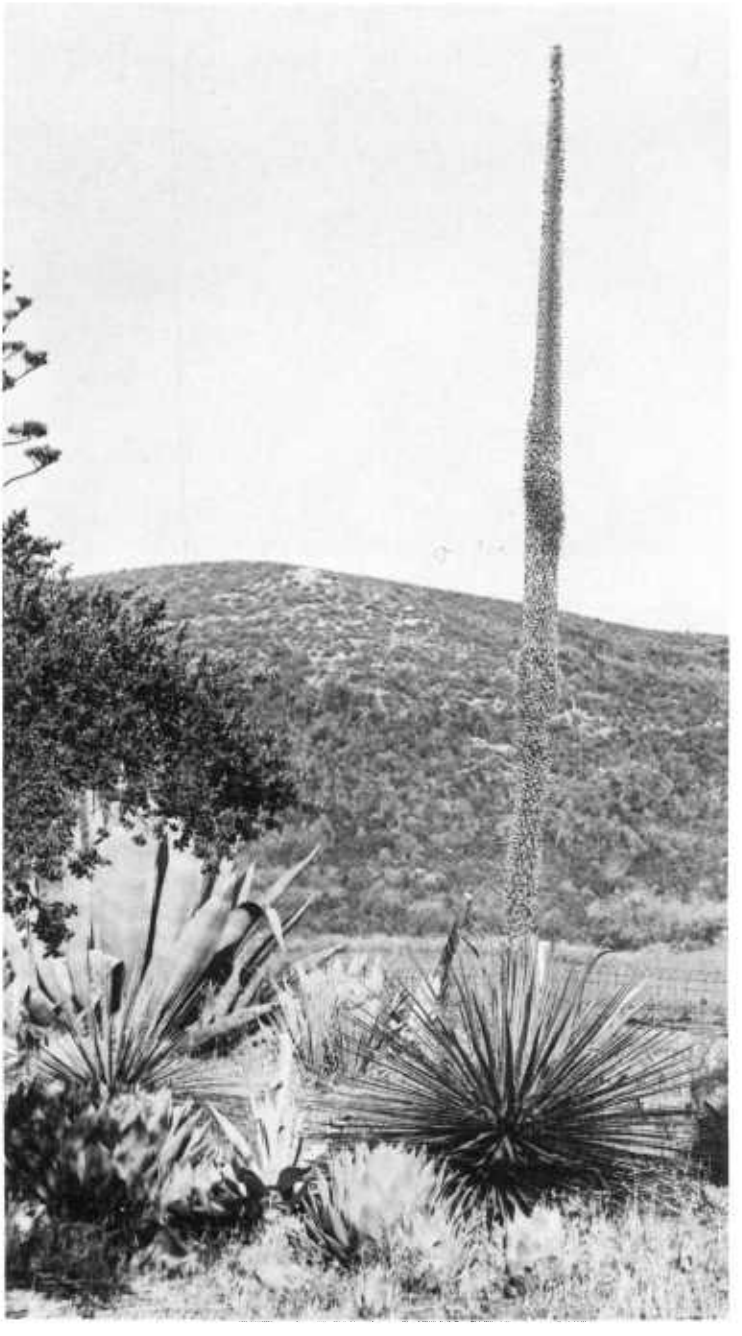
The flower proportions with the larger broader tepals, the green flower color, the elongate leaves, and the large size of the rosettes together with minor differences appear sufficient to separate this northwestern group as a species. The bud printing is less distinct than in most other filiferous agaves.

The name "chahuiqui" was applied to the plant on Sierra Guicorichi and is obviously of Indian origin, but I have no notes on local uses. The normal lifespan of this species appears to be 18 to 25 years, as the young plants, assumed to be 3 to 5 years old when collected in 1948, did not flower until 18 and 21 years later. In 1966 two plants at the Huntington Botanic Garden also flowered, but starting in May, about 1 month earlier than my plant at Murrieta (fig. 7). These were probably from my 1951 collection. It forms a handsome plant in the garden, the copious white threads among the leaves being curiously attractive, and because of the larger size would be more suitable than other Filiferae for landscaping grounds. It should be more cold hardy than other members of the Filiferae, as it grows in sites of the higher Chihuahua mountains where snow falls in winter. It showed no frost damage during the 15 years in Murrieta where winter lows reached 24° F.



PN-2108, PN-2109

FIGURE 6.—*Agave multifilifera: Upper,* on the bracciated lava of Sierra Charuco, the type locality, with one plant of *A. vilmoriniana; lower,* copious threads in the rosette.



PN-2110

FIGURE 7.—*Agave multifilifera* in flower at Murrieta, Calif., July 1966; 18 years from a small transplant.

***Agave polianthiflora* Gentry, sp. nov.** **Figure 8**

Small, single or cespitose rosettes 10–20 cm. high and 20–30 cm. broad; leaves 10–20 × 1–1.3 cm., linear lanceolate, widest in the middle, plane above, convex below, green, white bud-printed above and below, the margin conspicuously white-filiferous and minutely toothed near the base; spine 7–10 mm. long, grayish, weak; spike 12–20 dm. tall, stalk red, bearing flowers above the middle; bracts 1–2 cm. long, lanceolate, subulate, chartaceous; flowers 40–45 mm. long, short-pedicellate, usually in pairs, or 1 or 3, at a node, pruinose pink, long-tubular, subtended by scarious, triangular bractlets 3–6 mm. long; ovary 9–12 mm. long, red, ovoid; tube 28– 32 mm. long, 7–8 mm. wide at the top, very narrow and curved below; tepals reduced to triangular lobes of the tube, subequal, 3–4 mm. long; filaments, inserted 5–6 mm. above base of tube; stamens short, reddish before anthesis, yellow afterwards, shortly exserted; pistils exserted before anthesis, slender; capsules round to ovoid, 10–15 mm. long, apiculate, pruinose, rugose; seeds black, lucid, thick, 3.5–4 × 2.5–3 mm.

Type—*Gentry 8013,* high rocky rims around Arroyo Hondo, Sierra Charuco, Chihuahua, Apr. 17–25, 1948, and cultivated at Murrieta, Calif., flowering there in June 1957, deposited in U.S. Natl. Herbarium No. 2549705. SONORA: Sierra Saguaribo, Dec. 26, 1951, *Gentry 11384* (live pl. only); Canyon de la Escalera (loop of the Bavispe River), June 23, 1940, *White 2820* (lf. & fl.); Sierra Yecora, *Felger* (live pl.). CHIHUAHUA: San Jose de Pinal, Sept. 22, 1936, *Gentry 2850* (capsules); Arroyo Hondo, Sierra Charuco, Mar. 6–7, 1951, *Gentry 10229;* Majalca, alt. 6,000 feet, June 24, 1936, *LeSueur* 572 (lf. & fl.). It occurs infrequently in small clones on rocky outcrops in the pine and oak forests at elevations between 4,000 and 6,500 feet from the Rio Bavispe south on both sides of the Sonora-Chihuahua border. (Fig. 9, *left.*)

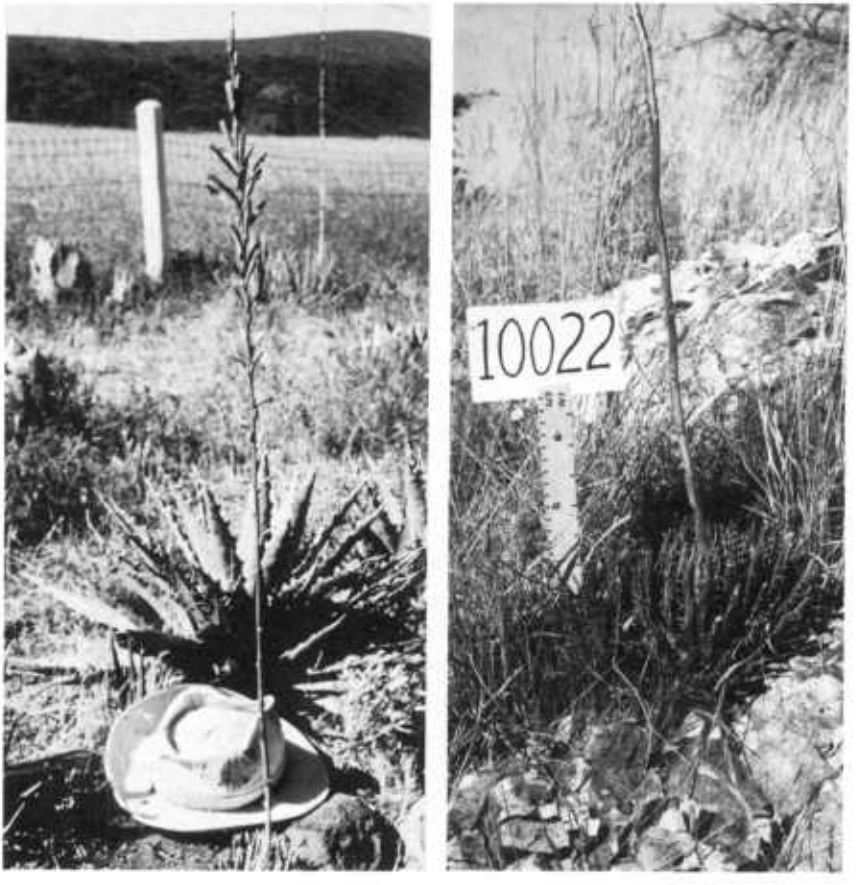
Planta parva, caule singulo vel caespitosulo; foliis viridibus, diagonaliter striati maculatis, albo-filiferis, lineari-lanceolatis, 8–18 cm. longis, 1–1.3 cm. latis, parvi dentatis ad basim; spina terminali parva, grisea, 6–8 mm. longa; scapo inflorescentia inclusa 12–20 dm. alto, virgato; bracteis 1–2 cm. longis lanceolatis, subulatis, chartaceis; bracteolis minutis, 3–6 mm. longis, triangulari-acutis; floribus puniceis roseis, longi-tubiformibus, 40–45 mm. longis; ovario brevi, ovato, 9–12 mm. longo; tubo 28–32 mm. longo, 7–8 mm. diam., ad basim aliquantulum curvato; segmentis subaequalibus, 3–4 mm. longis, 3 mm. latis, imbricatis; filamentis 30–32 mm. longis, roseis, intra tubo profunde insertis; antheris 6–8 mm. longis, post dehiscentiam luteis; capsulis ovatis, 10–15 mm. longis, 8–11 mm. latis, apiculatis, rugosis; seminibus nigris, lucidis 3.5–4 × 2.5–3 mm. crassis.

FIGURE 8.—*Agave polianthiflora:* Spike and leaves × ⅓; spine, flower cluster, and flower section slightly enlarged. Drawn from Gentry 8013.

The long, tubular, red or pink flower with its very short tepal lobes distinguishes this small agave from all others. The red pigment is made dusky with a pruinose overlay. The flowering shaft is also reddish. The flowers closely resemble those of the genus *Polianthes,* whence the specific name. Were it not for the agavoid leaves and the exserted filaments, this plant could be placed in

Polianthes. It is also unlike any other *Agave* I have observed in not having a proterandrous flower, as the pistil in this plant is exserted before anther dehiscence.

The leaves on the smaller rosettes of *A. polianthiflora* are scarcely separable from those of *A. parviflora* (fig. 10). In moist or more fertile situations and if watered frequently in cultivation, the leaves become much larger than in its natural habitat. The Felger collection from Yecora has unusually broad coarse leaves. In "Rio Mayo Plants" (*13*), *A. polianthiflora* was reported doubtfully as *A. hartmanii* S. Wats. Watson described that taxon from a growing plant in the now extinct Cambridge Botanical Garden, collected originally by Hartmen and Lloyd from an unspecified locality in the northern Sierra Madre Occidental of Sonora or



PN–2111, PN–2112

FIGURE 9.—*Left, Agave polianthiflora* in flower at Murrieta, Calif.; *right, A. parviflora* near type locality in Arizona.

Chihuahua on the Lumholtz expedition of the 1890's. Because no herbarium specimen was prepared and the disposition of the garden plant is unknown, it has not been possible to orient Watson's species. Watson's brief description could apply to *A. parviflora*, to *A. polianthiflora*, or to another small filiferous rosette related to *A. filifera* Salm., all growing in the same region. These taxa can be identified certainly only by their flowers. Wiggin's citation of *A. hartmanii* (*42*), based on a collection near Matapé, is referrable to *A. pariflora flexiflora*. It, therefore, seems appropriate to drop Watson's name as a *nomen confusum*.

The Warihio Indian name for this plant is "taiehcholi." They reported it as a good source of sweet food when pit baked, and the flowering stalks were formerly used as arrow shafts. The Rio Mayo Mexicans refer to the small plants as "mescalitos." The species appears limited naturally to the higher elevations of the mountains, 4,000 to 6,500 feet, growing on rocky sites in the open pine and oak forests. It is not common, being found in small and distant colonies. It makes a distinctive pot ornamental, but should be watered very sparingly and given full sunlight, or the leaves become etiolated, even floppy, and the rosette loses its diminutive and attractive compactness. The filiferous leaves are green with white diagonal brushlike markings formed by bud printing of the white, waxy exudate secreted in the growing bud.

Jacobsen (*28*) gives an illustration of this plant as *A. parviflora*.

Agave parviflora Torr. ssp. *parviflora* — Figure 10

***Agave parviflora* Torr., United States and Mexico Boundary Bot. 214. 1859.**

Very small, single or cespitose rosettes 10–15 cm. high and 15–20 cm. broad; leaves 6–10 × 0.8–1 cm., oblong-linear, widest at or above the middle, plane above, convex below, green, white bud-printed above and below, the margin conspicuously white-filiferous and minutely toothed near the base; spine weak-subulate, 5–8 mm. long, brown to grayish white; spike 10–18 dm. tall, laxly flowered through upper half of shaft, which is frequently reddish; bracts with lowest flowers 1–3 cm. long, much smaller above, scarious, long-subulate from a broad deltoid base, ephemeral; flowers pale yellow, in 2's, 3's or 4's, 13–15 mm. long; ovary proper 4–5 mm. long; neck 2 mm. long; tube 5 mm. long, urceolate; tepals 2–3 mm. long, the outer slightly longer than the inner, the latter much broader than long, 1.5 × 3–4 mm. and abruptly narrowed

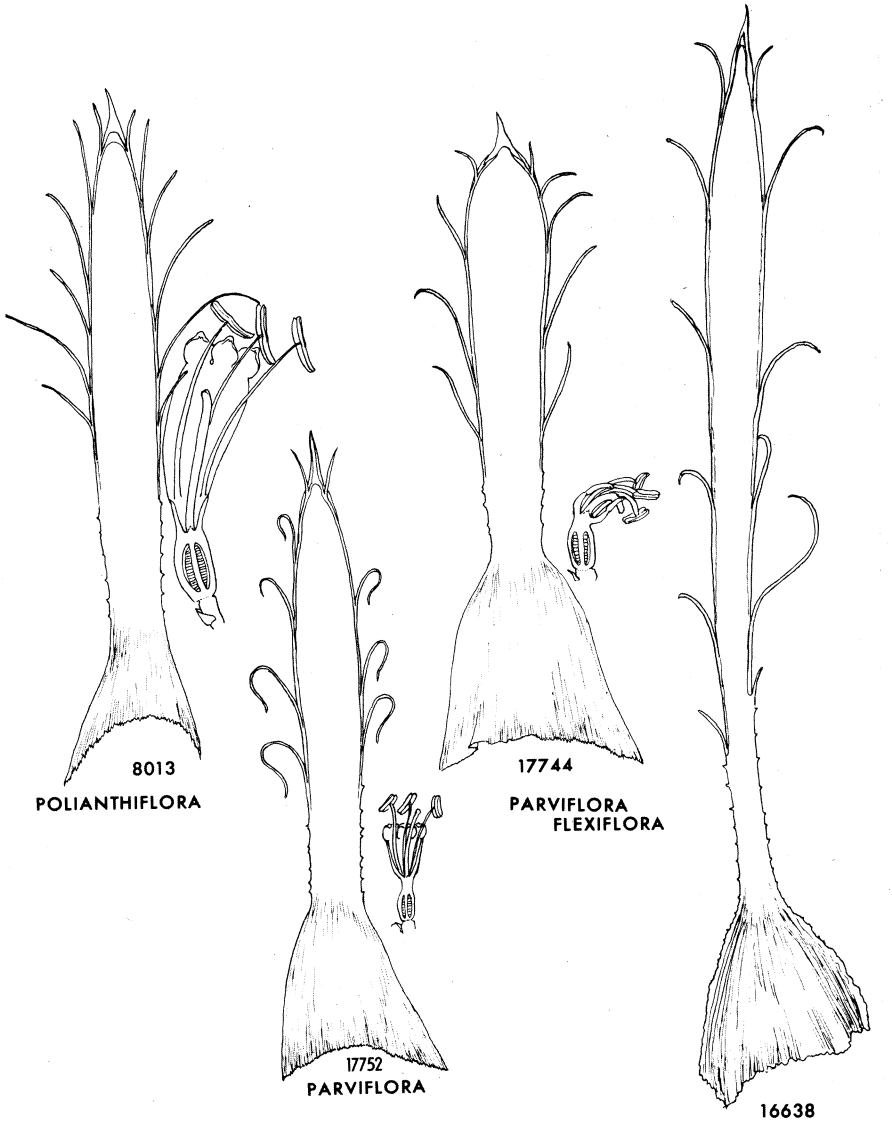


FIGURE 10.—The similar leaves of three agaves, which are certainly distinguishable as three taxa only by their flowers. *A. parviflora flexiflora* has two leaf forms.

below in the tepal sinus, all erect to incurved; filaments erect 10–12 mm. long, inserted at base of tube; anthers 5–6 mm. long; capsules orbicular to oblong, 6–10 mm. in diameter, sessile to short pedicellate, shortly beaked; seeds half-round, black, wedge-shaped,

3 mm. long on the thin flat edge, 2.5 mm. in diameter, much thickened on the curved side.

Type—Collected by Schott in the "Pajarito Mountains, Sonora," which was located by Trelease (*48*) as near the international boundary marker No. 129, between Sonora and Arizona, 10–15 miles west of Nogales. Locally, these mountains are now referred to as the "Peña Blanca Mountains" and on some roadmaps are shown as the "Atasco Mountains." *Peebles 11444* and *Gentry 10022* and *17752,* about 11 miles southeast of Ruby, Ariz., are on this same mountain and topotypic (fig. 9, *right*). More recently *A. parviflora* was found 16 miles northeast of Nogales along Arroyo Sonoita, Arizona, *Gentry* and *Kaiser 19900,* Apr. 10, 1963, alt. about 4,000 feet on rocky open slope in oak woodland. SONORA: 18.3 miles west of Moctezuma along road to Mazochahui, alt. about 3,000 feet, July 18, 1960 *Felger 3492* (lf. & fl.); "lower edge of oaks on N-facing slopes, inflo. ca. 6–10 ft. high." Inconspicuous, the plant has been overlooked by collectors and probably has a much denser distribution than indicated by the limited collections.

It flowers in June at the height of the spring dry season. Occasionally the inflorescence becomes diffusely racemose with numerous, strictly ascending, slender, lateral branches 5–10 cm. long. With *A. pumila* Baker, it is among the smallest of agaves.

***Agave parviflora* subsp. *flexiflora* Gentry, ssp. nov.**

Small, mostly single rosettes with filiferous, dimorphic, white bud-printed leaves; leaves linear or lanceolate, 6–10 × 1 cm. or 15–18 × 1.2 cm., plane above, convex below, short-acuminate, the margin minutely toothed near the base; spine small, weak, whitish, 5–8 mm. long; spikes slender, 15–25 dm. tall, laxly flowered, with small, triangular, scarious, caducous bracts; flowers 1–3 at a node, mostly geminate, short-pedicellate, yellow, saccate, 14–17 mm. long, the corolla with anthers and pistil flexed downward at anthesis; ovary 6–8 mm. long, fusiform; tube 3–4 mm. long; tepals 3.5–5 mm. long, broadly lanceolate, obtuse the inner sharply

Planta parva, caule singulo vel caespitoso; foliis viridibus, striati-maculatis, albo-filiferis, lineari-lanceolatis, 10–18 cm. longis, 1–1.2 cm. latis, paucidentatis ad basim; spina terminali parva, grisea, 5–8 mm. longa; scapo inflorescentia inclusa 15–25 dm. alto, virgato; bracteis chartaceis, caducis, brevi-triangulatis; floribus reflexi-saccatis, luteis; ovario 6–8 mm. longo, luteo-viridi, fusiformo; tubo 3–4 mm. longo; segmentis subaequalibus, luteis, 3.5–5 mm. longis, ovati-lanceolatis, obtusis; filamentis 14–16 mm. longis, ad basim tubi insertis; antheris luteis, 5–6 mm. longis; capsula et semina non vidi.

keeled and with broad hyaline margins, slightly shorter than the outer; filaments 14–16 mm. long, inserted in base of tube; anthers 5–6 mm. long, yellow; capsules and seeds not seen.

Type—*Gentry 16638,* collected 15 miles east of Guasabas along road to Huachinera, Sonora, Mexico, May 20, 1957, on volcanic rocks in oak woodland, alt. about 4,000 feet, deposited in U.S. Natl. Herbarium, No. 2549710. SONORA: 6–8 miles north of Bacadéhuachi, May 21, 1957, *Gentry 16643* (fl.); Ures of Moctezuma, *Gentry 16655* (live pl.); 3–4 miles northeast of Matapé in savanilla, alt. 2,000–2,500 feet, May 13, 1957, *Gentry 16601* (buds) and July 2, 1959, *Gentry 17744* (fl.); western slope of Sierra Batuc, 5 miles north of Matapé, Sept. 8, 1941, *Wiggins & Rollins 413* (lf. & cap.); 9.3 miles northwest of Nacori Chico, alt. about 3,450 feet, June 6, 1960, *Felger & Marshall 3305* (fl. & lf.), rocky low hills, grassland. The habitat is the short, sparse, open, grama grasslands with gravelly clay soils derived from volcanics at elevations between 2,000 and 4,500 feet.

A. parviflora flexiflora differs from *A. parviflora parviflora* in the downward flexed flowers, in the longer tepals, and in the tendency to develop longer leaves (fig. 10). This last character is conspicuous in the collections east of Guasabas, but is seldom apparent in the collections west of the Bavispe and Moctezuma Rivers, in which the leaves are not separable from typical *A. parviflora.* The downward flexing of the flower develops with anthesis, becoming marked with the downward flexure of the growing pistil. Carpenter bees enter the flower from below the perianth.

Local names for these diminutive agaves were reported as "tauta," "tautilla," and "sóbari" or "sóbali." They were said to be among the sweetest and most edible of their kind when properly cooked, but were rarely used because of their small size. All forms of the species are attractive as pot ornamentals. Carpenter bees were working the flowers assiduously in the populations east of Guasabas at the time of specimen collections.

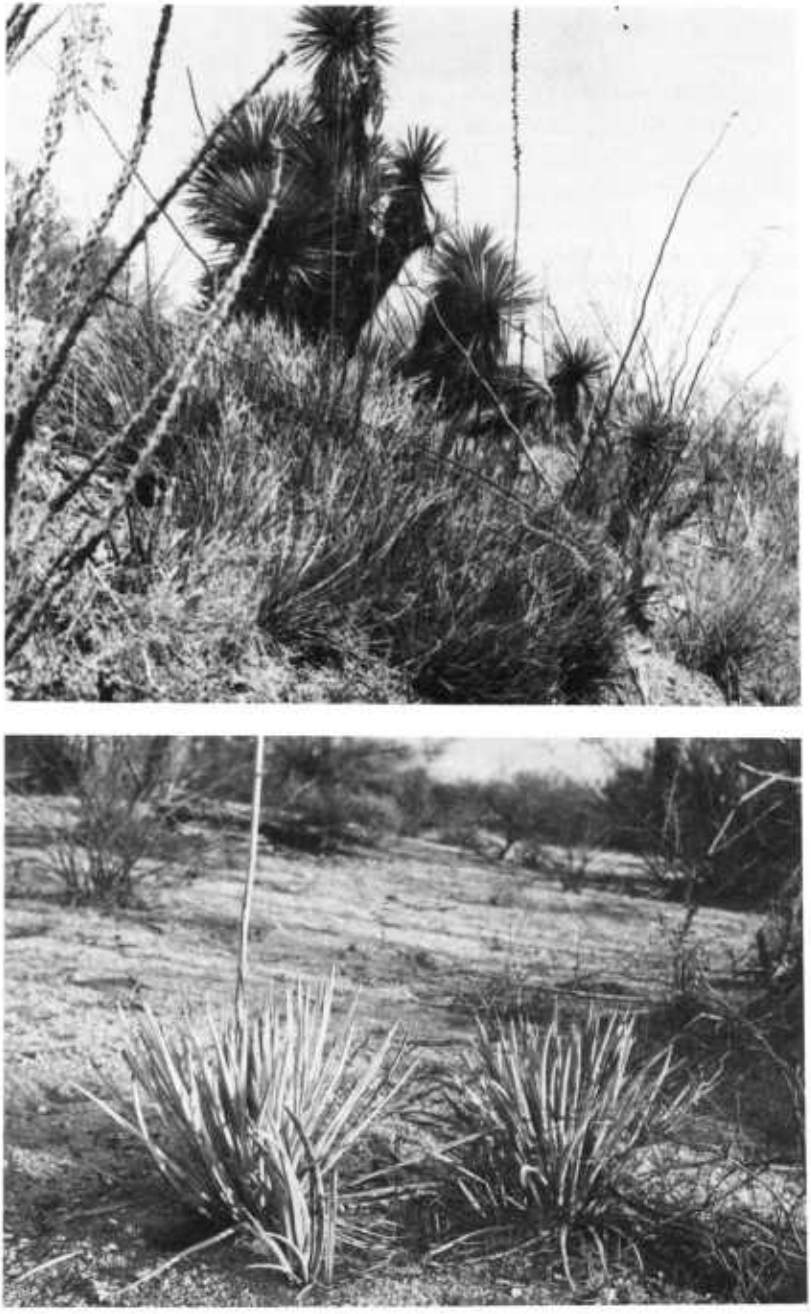
Agave schottii Engelm., Acad. Sci. St. Louis Trans. 3: 307. 1875. Figure 11

Densely cespitose, small, yellowish green to green rosettes; leaves narrowly linear, 0.7–1.2 × 25–40 cm., widest at the base, straight, incurved, or falcate, pliant, flat or somewhat convex above, deeply convex below, smooth above and below, margins with a narrow brown border and sparse brittle threads; spine 8–12 mm. long, grayish, fine, rather weak and brittle; spikes 1.8–2.5 m. tall, slender, frequently crooked, flowering in upper ⅓ to

¼ of shaft; bracts straw-colored, filiform, acicular, 2–4 cm. long; flowers yellow 1, 2, or 3 on stout pedicels 3–5 mm. long with setaceous bracteoles 10–15 mm. long on lower spike but shorter above; ovary greenish yellow, 8–10 mm. long with neck 4–6 mm. long; tube deeply funnelform, 9–12 mm. long, very narrow below; tepals 10–16 mm. long, yellow, unequally spreading at anthesis, the outer without a keel; filaments 15–20 mm. long, inserted high in tube at 6–9 mm. above base of tube; anthers light yellow, 10–15 mm. long; capsule 10–20 mm. long, rounded to apiculate; seeds 3–3.5 mm. along the straighter thinner edge, with a notch at one corner, variably thickened.

Type—Arthur Schott in 1855, Sierra del Pajarito in southern Arizona, flowering in August. Also collected on the same mountain is *Gentry 17751,* about 12 miles west of Nogales along road to Ruby, flowering in July 1959. SONORA: Western foothills of Sierra de la Caballera, about 10 miles east of Colonia Morelos, alt. 3,400 feet, Sept. 22, 1941, *White 4466* (lf. & fr.). Between Santa Rosa canyon and Bavispe, July 20, 1938, *White 628* (lf. & fl.) ; about 16 miles southeast of Magdalena along road to Cucurpe by Sierra Baviso, May 22, 1960, *Felger 3276* (lf. & fl.); Rancho Primavera, west of Sierra Jojoba, July 24, 1966, *Gentry & Weber 21988* (fl.). The following leaf collections are tentatively assigned to this species. SONORA: Picú Pass, 18–20 miles northeast of Libertad, *MacDougal & Shreve 14; Wiggins 6097;* Port Libertad, *MacDougal & Shreve s.n.* In northeastern Sonora, colonies of this species were observed on the lower slopes of Sierra Huachinera near the Chihuahua border. The distribution in Chihuahua is unknown. It is probably common in the oak and grama grassland highlands of northern Sonora at elevations between 4,000 and 6,000 feet, as in adjacent Arizona and New Mexico. It is less common about the desert mountains of northwestern Sonora, where it has been observed along arroyos and outwash bajadas at elevations between 1,500 and 2,500 feet. The western limit appears to be in the low Picú Mountains some 15 to 20 miles east of Libertad. (Fig. 11.)

The slender, deep tube, together with the narrow, ovarian neck, gives the flower a characteristically long, tubular appearance. The ratio of tube length to tepal length, however, is variable, but the tube usually equals and sometimes exceeds the tepals in length. In gardens, *A. schottii* is easily confused with narrow-leaved forms of *A. falcata* and *A. felgeri,* but all three are readily separated by their respective flowers.



PN-2113, PN-2114

FIGURE 11.—*Upper, Agave schottii* with *Yucca peninsularis* and *Fouquieria splendens* in pass by Sierra Baviso, 16 miles southeast of Magdalena; *lower, A. schottii* at road fork north of El Datil.

Among Spanish-speaking people these small, narrow-leaved, nondescript agaves are known as "amole" or "amoliyo" and they are employed locally for washing clothes. They are not eaten because of the insignificant size of the "heads" (stems) or because of bitter constitutents. The leaves were found to contain 0.5–1.2 percent sapogenins, mainly gitogenin and chlorogenin. The plants have little if any value as ornamentals. They are so abundant on some cattle ranges in southeastern Arizona that cattlemen regard them with disfavor. However, they contribute a great deal towards building and holding soil on the steep, rocky slopes they inhabit.

***Agave felgeri* Gentry, sp. nov.** **Figure 12**

Small, green to yellow-green, surculose rosettes with rather few leaves forming rather closely cespitose clones; leaves 25–35 × .7–1.5 cm., linear to narrowly lanceolate, straight or falcate, plane above, convex below, widest at the base, faintly bud-printed and frequently with a pale median stripe, epidermis rugose or scabrous above, the margin with a narrow brown border weekly filiferous, smooth; spine small, weak, 8–15 mm. long, gray; spikes 1.5–2.5 m. tall, flowering in upper ¼ of shaft; bracts chartaceous, the lower ones 2–3 cm. long, very narrow; pedicels strong, single or bifurcate, 2–5 mm. long; old dry flowers (relaxed) 25–30 mm. long; ovary 12–14 mm. long; tube 2–4 mm. deep; tepals 10–12 mm. long, about equal, linear; filaments 20–25 mm. long inserted in orifice of tube; capsules oblong or obovoid, narrowed towards the base, apiculate, 15–20 × 9–12 mm.; seeds irregular, 4–5 × 3 mm., thick, angulate, wrinkled, the hilar notch narrow and deep.

Type—*Gentry 11343* Bahia San Carlos, District Guaymas, Sonora, Dec. 13, 1951 (lf. & cap.) with coastal shrub on volcanic agglomerate (fig. 12), deposited in U.S. Natl. Herbarium No. 2540143 and No. 2540144. Same locality: Nov. 7, 1954, *Felger 650* (lf. & cap.) and at later dates, *Felger 2492; Felger, Kleine, & Russell 11456; Felger, Thomas, & Russell 12121.* SONORA:

Planta rhizomati-caespitosa, parva, 20–30 cm. alta, 30–40 cm. lata; foliis paucis, pallido-viridibus, saepe medio pallido-lutis-striatibus, linearibus, 25–35 × .7–1.5 cm; asperibus sparse brunneofiliferis, planus supra convexus infra; spina terminali parva, 8–15 mm. longa, grisea; scapo inflorescentia inclusa 1.5–2.5 m. alto, virgato; bracteis inferioris 2–3 cm. longis, chartaceis; bracteolis 5–8 mm. longis; floris 25–30 mm. longis; ovario 12–14 mm. longo; tubo 2–4 mm. longo; segmentis aequalibus 10–12 mm. longis, linearis; filimentis 20–25 mm. longis, ad apicem tubi insertis; capsulis oblongis vel obovatis, apiculatis, 15–20 × 9–12 mm.; seminibus 4–5 × 3 mm. crassis rugosis angulatis.

PN–2115, PN–2116

FIGURE 12.—Broad-leaved form of *Agave felgeri at* San Carlos Bay. Spikes *(right)* were carried to beach for photographing.

Rancho Bachaca, 15–18 miles east of Navojoa, Dec. 19, 1951, *Gentry 11366* (fl. & cap.) ; Sept. 16, 1959, *Gentry 17822* (lf. & dry fl.). Collections from near Libertad in northern Sonora, *D. T. McDougal* in 1923 and *Wiggins 6097,* Oct. 26, 1932, may be assignable to this species, and if so, indicate a narrow coastal range through middle Sonora. I have seen *A. felgeri* for sure only in the thin parched rocky soil on volcanic ledges near the coast.

In habit, size, and leaf form this proposed species resembles *A. schottii,* especially in the forms having narrow leaves, as those at the Rancho Bachaca. However, the short tube with the relatively long tepals, 3–4 times as long as the tube, indicate a basic difference between the highland *A. schottii* and the coastal *A. felgeri.* Fresh flowers are needed to judge the relationships. Its flowering season appears to be June and July, but the San Carlos Bay population certainly does not flower every year, as several trips to that easily accessible locality have shown. (Fig. 12.)

At Rancho Bachaca (Mayo, meaning bad water) the people called this plant "mescalito" and said they did not use it. I found it there in one isolated colony upon one of the bald volcanic domes that characterize the place. Analyses of the rosettes yielded about 1 percent sapogenins, that from Rancho Bachaca consisting wholly of chlorogenin, while that from the Bahia San Carlos material contained 67 percent chlorogenin and 33 percent tigogenin.

It is a pleasure to commemorate the name of Richard Felger by giving his name to this species, in recognition of his sustained interest in this *Agave* and of his years of labor with the Sonoran biota as a graduate student of the University of Arizona.

For distribution of *Agave multifilifera* and the Parviflorae group, see figure 13.

Agave vilmoriniana Berger, in Fedde's, Repert. Spec. Nov. Regni Veg. 12: 503. 1913. Figure 14

Agave mayoensis Gentry, Rio Mayo Plants, Carnegie Inst. Wash. Pub. 527, p. 94. 1942.

Short-caulescent, light green to yellowish green, single rosettes, 1 m. tall × 2 m. broad with toothless, arching, deeply guttered, pliant leaves, 90–180 × 7–10 cm., broadest at base, linear-lanceolate, long acuminate, heavily thickened towards the base, concave to conduplicate above; margin unarmed with a fine brown continuous border about 1 mm. wide, scaly in age; epidermis smooth; spine acicular, brown to grayish brown, 1–2 cm. long; spike 3–5 m. tall, densely flowered from 1–2 m. above base, bulbiferous or

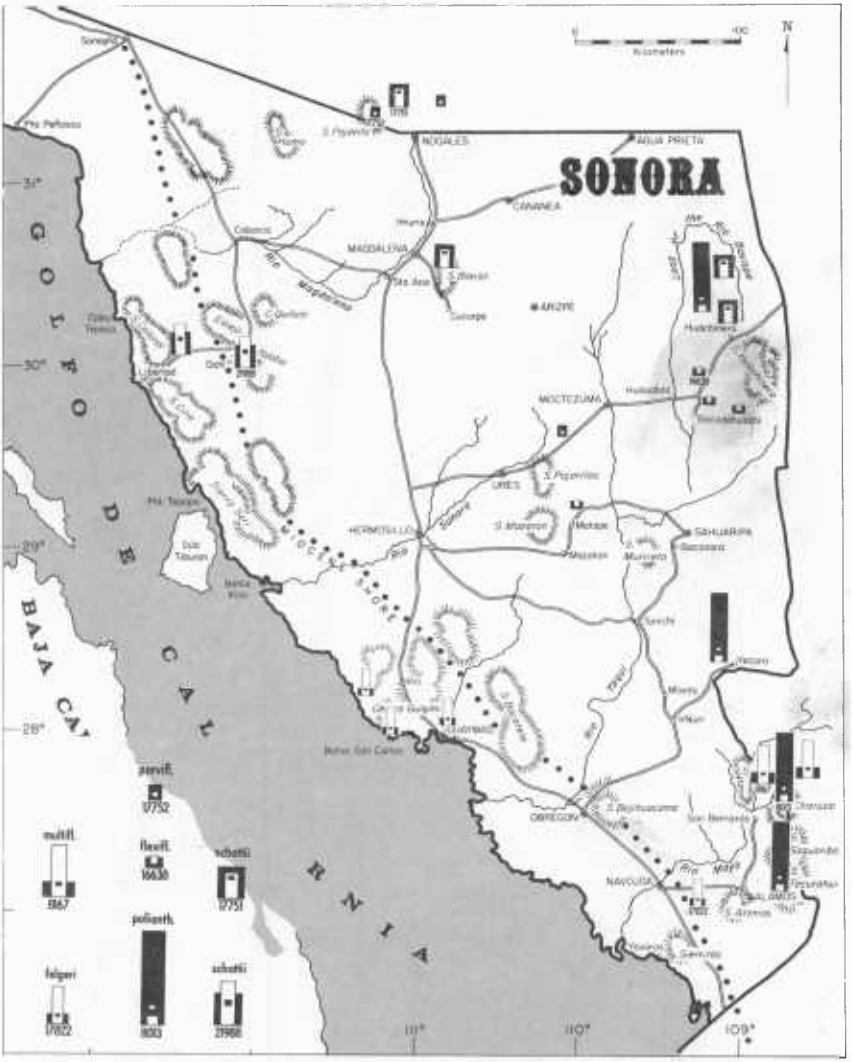


FIGURE 13.—Distribution of *Agave multifilifera* and the Parviflorae group in Sonora, represented by their ideographs. Ideographs with numbers indicate flower collection at the locality occupied. (See p. 37.)

nonbulbiferous; lower bracts 10–20 cm. long, scarious, acicular, brownish towards the brittle tip; upper bracts 1–2 cm. long; bracteoles of the pedicels deltoid, 2–3 mm. long; pedicels 8–20 mm. long, 1–2 bifurcate; flowers yellow, 35–40 mm. long with a shallow open tube; ovary 15–20 mm. long including neck (3–4 mm.); tube 4 mm. long × 8–9 mm. wide; tepals 14–17 × 4–5 mm., nearly plane, ascending to spreading at anthesis, clasping the filaments

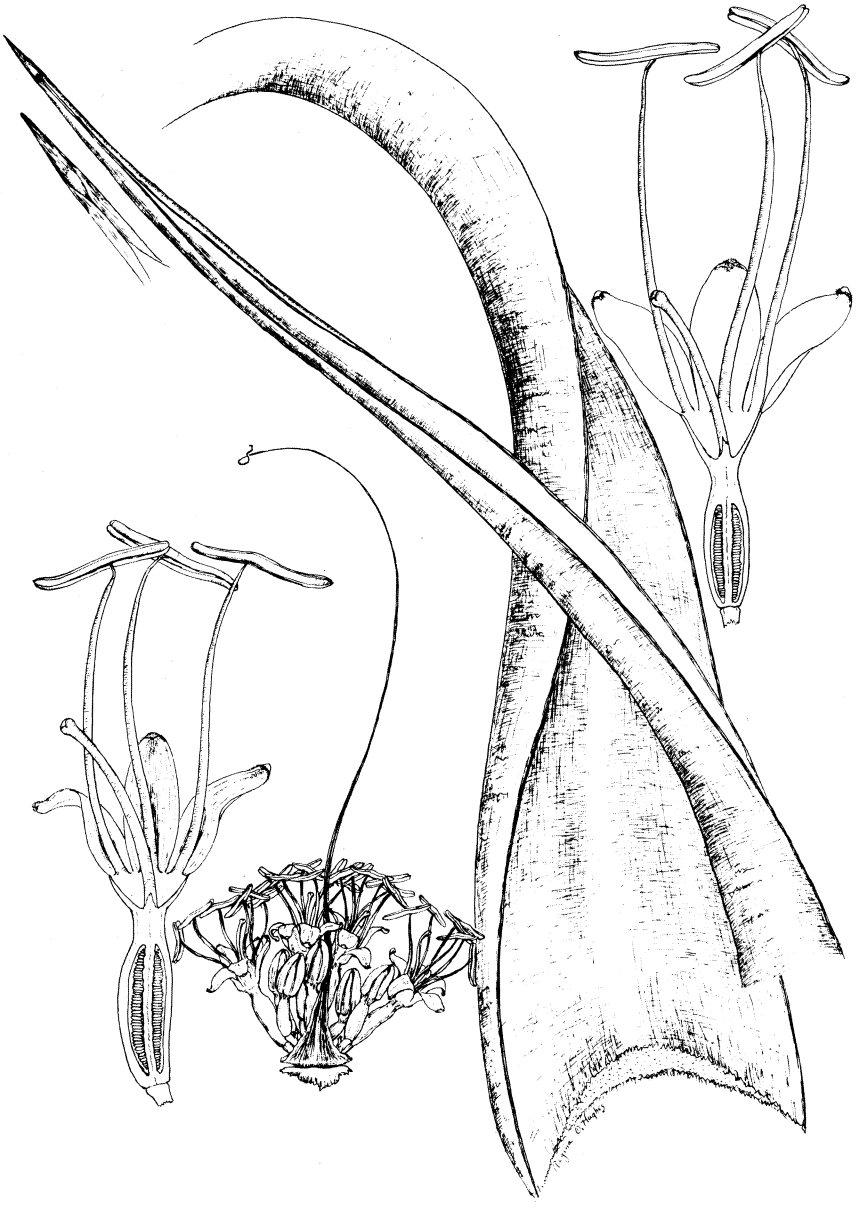
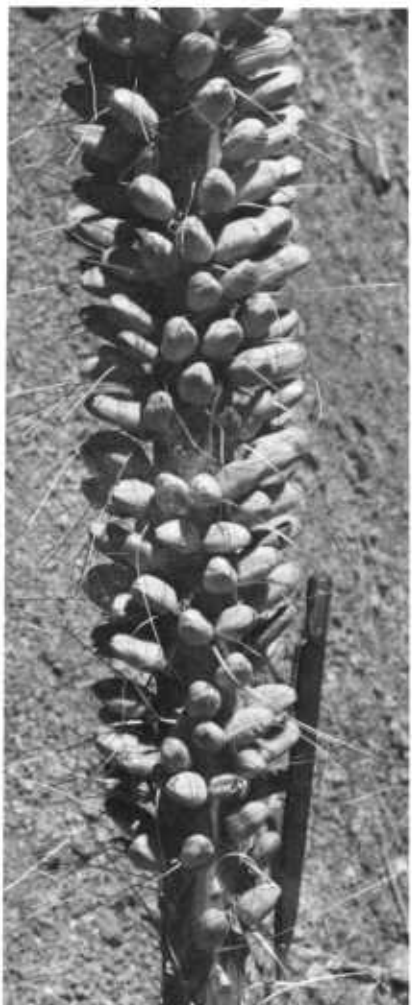


FIGURE 14.—*Agave vilmoriniana:* Lower and upper thirds of leaf (spine tip enlarged); flower cluster from lower part of spike about × ⅓; flower section slightly enlarged. Drawn from Gentry 10232. *Upper right, A. chrysoglossa:* Flower section slightly enlarged. Drawn from Gentry 19882.

in drying, equal; filaments 30–40 mm. long, inserted at upper edge of tube; anthers 16 mm. long.

Type—None cited. Berger reported it was collected in Mexico by Diguet. In an undated letter to J. N. Rose, fide copy in U.S. Natl. Herbarium, Berger wrote that the plant was collected by "Mr. Diguet for the Jardin des Plantes at Paris and which I named Agave vilmoriniana in 1913 in honour of M. Maurice de Vilmorin, an excellent man, in whose garden at Verreves I found this Agave for the first time. . . . The fruits in your photo resemble greatly those of A. ellemeetiana etc. of the same group 'Anoplagave.' It was not in cultivation at La Mortola and of course if I were still there I should be delighted to receive your plants." Rose had found the plant on the rim of the barranca near Guadalajara, Jalisco, July 9, 1899, *Rose & Hough 4833*, Hough having risked his life to obtain the specimen. As Diguet is known to have collected in the vicinity of Guadalajara, it is probable that this barranca is the type locality. There are two spines and a pencil sketch by Berger in the U.S. Natl. Herbarium. The flowers are described and shown here for the first time (figs. 14 and 15). SONORA: Arroyo Gochico, Rio Mayo, canyon cliffs in barranca forest, Apr. 5, 1938, *Gentry 3673* (fl.); also in Arroyo Gochico, 5 miles above San Bernardo, May 1, 1957, *Gentry 16531* (with bulbils & fl.); Rancho San Antonio, Sierra Tecurahui, May 20, 1966, *Barclay & Arguelles 2016* (fl. & lf.). "Abundant on bare rocky cliffs; pine-oak zone." CHIHUAHUA: High rocky rims and cliffs around Arroyo Hondo, Sierra Charuco, alt. 5,000-5,500 feet, March 6–7, 1951, *Gentry 10232* (lf. only). DURANGO: 8–10 miles south of Boca de Mezquital, along road from Durango to Mezquital, June 11, 1951, *Gentry & Gilly 10587* (lf.). (Figs. 16 and 17.)

A cliffdweller, the typical habitat of this handsome plant is the volcanic brecciated cliffs of the barrancas from southern Sonora south through Sinaloa and Durango to Jalisco and Aguascalientes, at altitudes between 2,000 and 5,500 feet. In the larger, deeper canyons it forms extensive vertical colonies, which, when viewed from a distance, resemble giant spiders on a wall. Individuals may be found upon gentler adjacent slopes in open light. The cliff situations are virtually frostless, but the open heights above 4,000 feet have sharp frosts. In southern California the plants have resisted overnight freezes as low as 24° F. They withstand protracted drought easily and will take in water during the chilling winter rains in California. Many of the cliff plants, for lack of soil, remain stunted through their lives, their maturation inhibited, and the inflorescence is feeble when at last it does appear.



PN–2117, PN–2118

FIGURE 15.—*Left, Agave vilmoriniana:* Bulbils growing out of flowering axils; *right, A. chrysoglossa:* seeding spike.

PN-2119

FIGURE 16.—*Agave vilmoriniana* along Arroyo Gochico in Rio Mayo country. Dried flowers hang, bleached and beardlike, on fruiting spikes.

PN–2120, PN–2121

FIGURE 17.—*Agave vilmoriniana: Upper*, plants 1 year old from bulbils at Huntington Botanical Garden; *lower*, maturing plant on Sierra Charuco, Sonora. Compare these deeply guttered leaves with those of *A. chrysoglossa* (fig. 18).

This species is distinguished by its unarmed, large, gracefully arching, deeply guttered leaves (fig. 17, *lower*). In Sonora and elsewhere it is known as "amole," and, like other plants of the name, is used in washing clothes and other fabrics. For this use, the old dried leaf bases on dead flowered plants are cut off about 6 or 8 inches above the base. The fibers in the lower butt are beaten and loosened by pounding with a rock, forming an effective brush with a built-in soap or detergent, which foams and cleans in water as one brushes. These brushes have been noted for sale in local markets of the Mexican west coast. The cleaning agent is principally the sapogenin, smilagenin, which by analyses was found to form 3–4.5 percent of the dry leaf, among the highest known for any agave leaf. Younger green leaves contain much less. For remarks on the commercial potential, see "Uses of Agave and Yucca," p. 9.

As an ornamental *A. vilmoriniana* lends itself well to design plantings and propagates readily from bulbils. The clone in the Huntington Botanical Garden in San Marino, Calif., forms mature flowering plants in 7 or 8 years from bulbils (fig. 17, *upper*). However, young plants collected on Sierra Charuco, *Gentry 10232,* and planted at Murrieta in 1951 did not flower until 1966—15 years later. The spike emerged soon after April 1 and reached about its full height in early May. The more rapid maturation in the Huntington Botanical Garden is apparently due to better culturing there and, perhaps, also to genetic early maturation factors. Capsules and seeds are also produced, hence, a given population may consist of both apomictic and sexual generations. This was noted in the Arroyo Gochico population (fig. 16). No rhizomatous offsets have ever been observed.

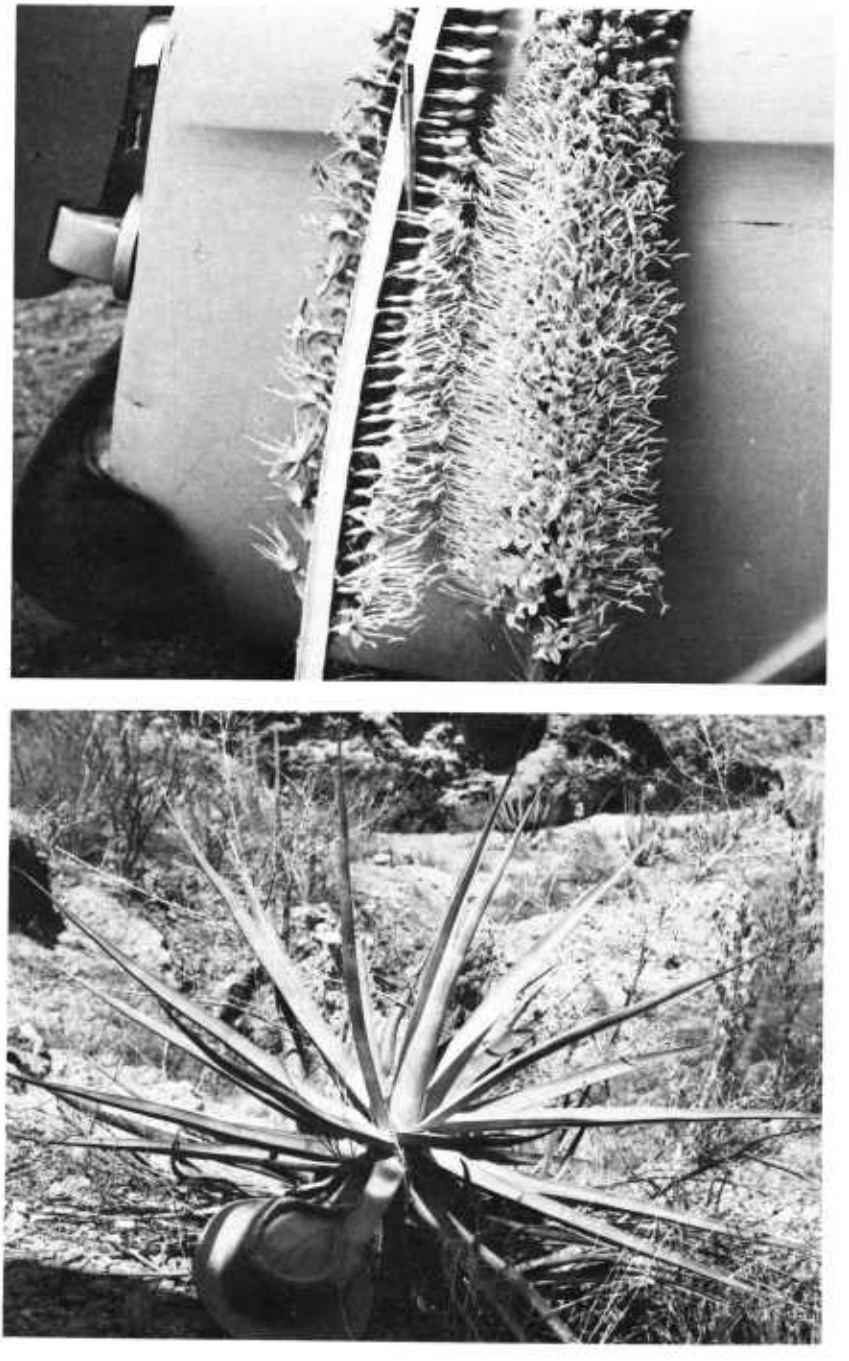
Agave chrysoglossa **I.M. Jtn., Calif. Acad. Sci. Proc., ser. 4, 12: 998. 1924.**

Single, short-stemmed, openly spreading, few-leaved, green rosettes, 1–1.3 × 2–2.4 m.; leaves 70–120 × 4–7 cm., wider at the base, straight or slightly curved, flat above, convex below, deflexed at maturity, light green, smooth, linear-lanceolate, toothless, with a thin brown fragile margin 1 mm. wide; spine 2–4 cm. long, acicular, brown, aging grayish, with a short fine groove at base above; spike mostly 2–4 m. tall, densely flowered in upper ¾; bracts dry, chartaceous, the lower ones exceeding the flowers; pedicels bifurcate, 10–15 mm. long, their bracteoles small, white-papery, curling; flowers yellow, 35–40 mm. long, gemminate; ovary 16–18 mm. long including neck 3–5 mm. long, slender,

scarcely grooved; tube shallow, 4–4.5 mm. deep, 9 mm. wide; tepals ovate, plane, outcurving at anthesis, clasping filaments in drying, thin, the outer 14–16 × 6 mm., keeled, the inner wider (8 mm.) and unkeeled; filaments 30–40 mm. long, inserted on the rim of tube at base of tepals; anthers 15 mm. long; capsules mostly oblong, 2 × 1 cm., short-apiculate, parallel-veined and slightly cross-ridged; seeds lunate, mostly 4–4.3 × 2.5–2.8 mm., 1–several wrinkles on faces, marginal wing low, firm, the hilar notch sharply angled (*Gentry 16611*).

Type—*I. M. Johnston 3123*, found flowering Apr. 17, 1921, on the rocky, granitic slopes of San Pedro Nolasco Island, Gulf of California; *Gentry 11349*, same locality, Dec. 16, 1951, without flowers. The following collections document it for the mainland. SONORA: 26 miles northwest of Sahuaripa, along the Rio Yaqui, May 24, 1957, *Gentry 16611*, (cap.); 14 miles south of Bacanora along road to Tonichi, May 16, 1957, *Gentry 16623*, (fl.); cerro 4–5 miles north of Bahia San Carlos, March 29, 1963, *Gentry 19882*, (fl.); San Pedro Bay, July 7, 1921, *Johnston 4338*, "common on rocky mountain side"; about 2 miles northwest of Bahia San Carlos along road to Bahia Algodones, riparian canyon with desert shrub and thorn scrub, Feb. 9, 1960, *Felger & Stronck 3113*. A few plants once observed in a lower canyon of Sierra de Alamos may belong to this species.

A. chrysoglossa is closely related to *A. vilmoriniana*, but the straight, narrow, plane leaves and nonbulbiferous inflorescence are sufficient to distinguish *A. chrysoglossa*, (fig. 18). *A. chrysoglossa* is the coastal or lowland relative of this alliance in Sonora, more xerophytic and at home upon the hot, frequently bare rock surfaces. It flowers from mid-March to mid-May during the spring dry season when air temperatures during the day usually rise to 100–110° F. I found the inland population about Bacanora in May to have prolific sets of maturing black seeds (fig. 15, *right*). Estimates based on partial seed and capsule counts indicated as many as 500,000 to 750,000 seeds per plant. It appears to be a free-seeding, cross-pollinated species, with the liquid nectar attracting animals during the thirsty season. Numerous insects, hummingbirds, and other kinds of birds were observed about the flowers. Johnston wrote of the island plants (loc. cit.), "When found it was enlivening the rocky mid-slopes of the island with spectacular tongues of color. The plants grew singly and produced dense elegant spicate floral clusters 1–2 m. long and 8–10 cm. broad which, due to their weight, almost invariably bent over with their tips nearly touching the ground." All mainland plants observed had erect spikes.



PN–2122, PN–2123

FIGURE 18.—*Agave chrysoglossa:* Sections of flowering spike and a typical plant, showing the flat upper surface of leaves, at San Carlos Bay, Sonora.

This *Agave,* also known as "amole," is almost as sapogenous as *A. vilmoriniana* and has the same local use for washing clothes. Small plants were transplanted from Bancanora to my Murrieta garden, where they have done well, but in 10 years they have not flowered.

***Agave ocahui* Gentry, sp. nov.** **Figure 19**

Short-caulescent, single, dense, green, yuccoid rosettes, 30–50 cm. tall, 50–100 cm. broad; leaves numerous, 25–70 cm. long, 1.5–2.5 cm. broad, widest at the base, linear-lanceolate, plane above, convex below, mostly stiff, erect to ascending, some older declined or falcate, the margin straight and lined with a very narrow, reddish-brown, firm border detachable on dried leaves, surface smooth, minutely, densely punctulate in fine lines; teeth none; spine weak, rather brittle, 1–2 cm. long, pruinose gray over brown; spike about 3 m. tall, slender, densely flowered from 1–1.5 m. above the base; flowers 30–35 mm. long, yellow, on short bifurcate pedicels; ovary 14–15 mm. long with short constricted neck; tube about 4 mm. deep, openly spreading; tepals subequal, 14–15 mm. long, 5 mm. wide, oblong, the tips outcurving; filaments 40 mm. long, yellow, inserted on base of tepals; anthers 14–15 mm. long, yellow (measurements from relaxed dried flowers) ; capsules small, 12–15 mm. long, 7–8 mm. broad, ovoid, apiculate, yellowish tan to reddish, tardily dehiscent; seeds small, 2.5–3 mm. long, 1.5–1.7 mm. wide, rather thick, half-ovate.

Type—*Gentry & Arguelles 16637,* deep volcanic canyon above (east of) Guasabas, Sonora, May 21, 1957, alt. about 4,000 feet, deposited in U.S. Natl. Herbarium No. 2549703 and No. 2549704. SONORA: Sierra Baviso, 16 miles southeast of Magdalena, near Canyon de Palmas, March 31, 1963, *Gentry & Arguelles 19886* (fr.); Ahuaje de Pescado, 8 miles east of Matapé, *Gentry & Arguelles 16603* (lf. for analysis), on rock cliff, the leaves green,

---

Planta brevicaulis, yuccoidea, 30–50 cm. alta, 50–100 cm. lata; foliis multis, 25–70 cm. longis, 1.5–2.5 cm. latis, lineari-lanceolatis, firmis, aliquando curvatis aut falcatis, supra plana, infra convexa; margine inermi, firmo, angusto, castaneo, continuato; spina terminali 1–2 cm. larga, grisea, fragili; scapo inflorescentia inclusa ca. 3 m. alto; pedicellis 5–8 mm. longis, bracteolis chartaceis, 5–20 mm. longis, filiformibus; floribus luteis, 30–35 mm. longis, densis; ovario 14–15 mm. longo, viridi, cylindrico; tubo ca. 4 mm. longo; segmentis subequalibus, 14–15 mm. longis, 5 mm. latis, oblongis, recurvatis; filamentis 40 mm. longis, ad basim segmenti insertis; antheris luteis, 14–15 mm. longis; capsula parva, 12–15 mm. longa, 7–8 mm. lata, ovata, apiculata; seminibus parvi, 2.5–3 mm. longis, 1.5–1.7 mm. latis, crassis, nigris, margine curvato angusto-alatis.

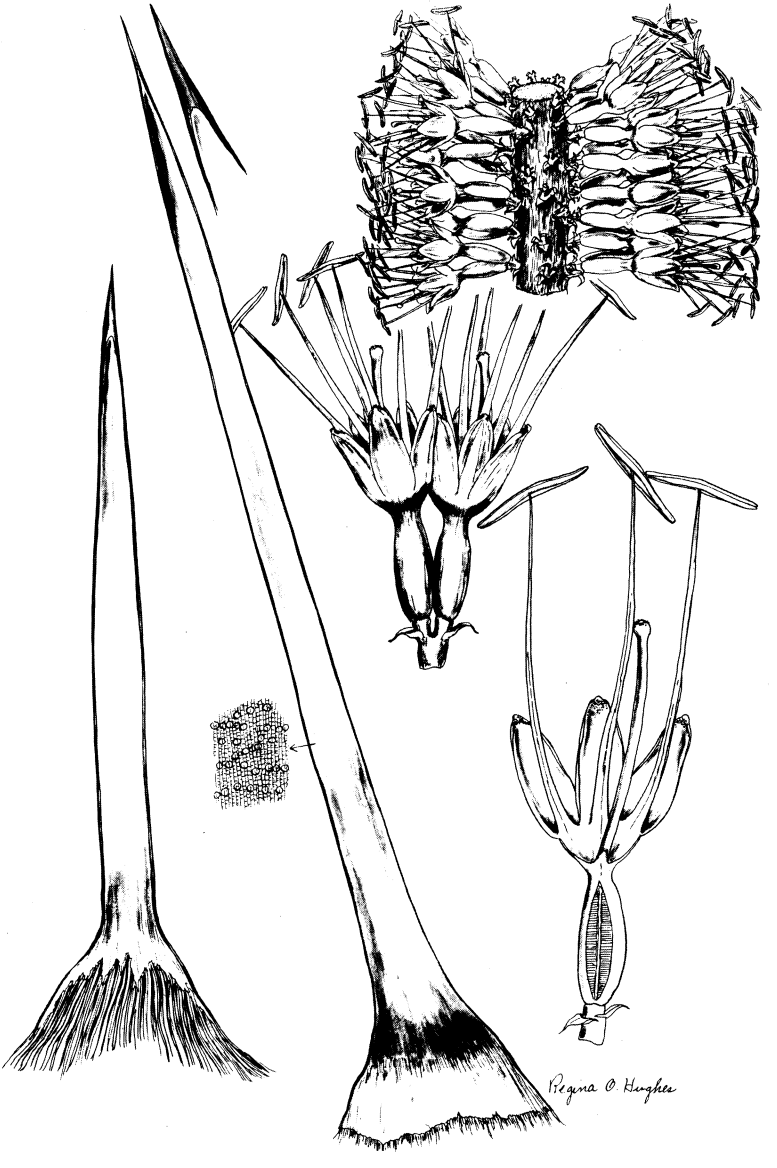
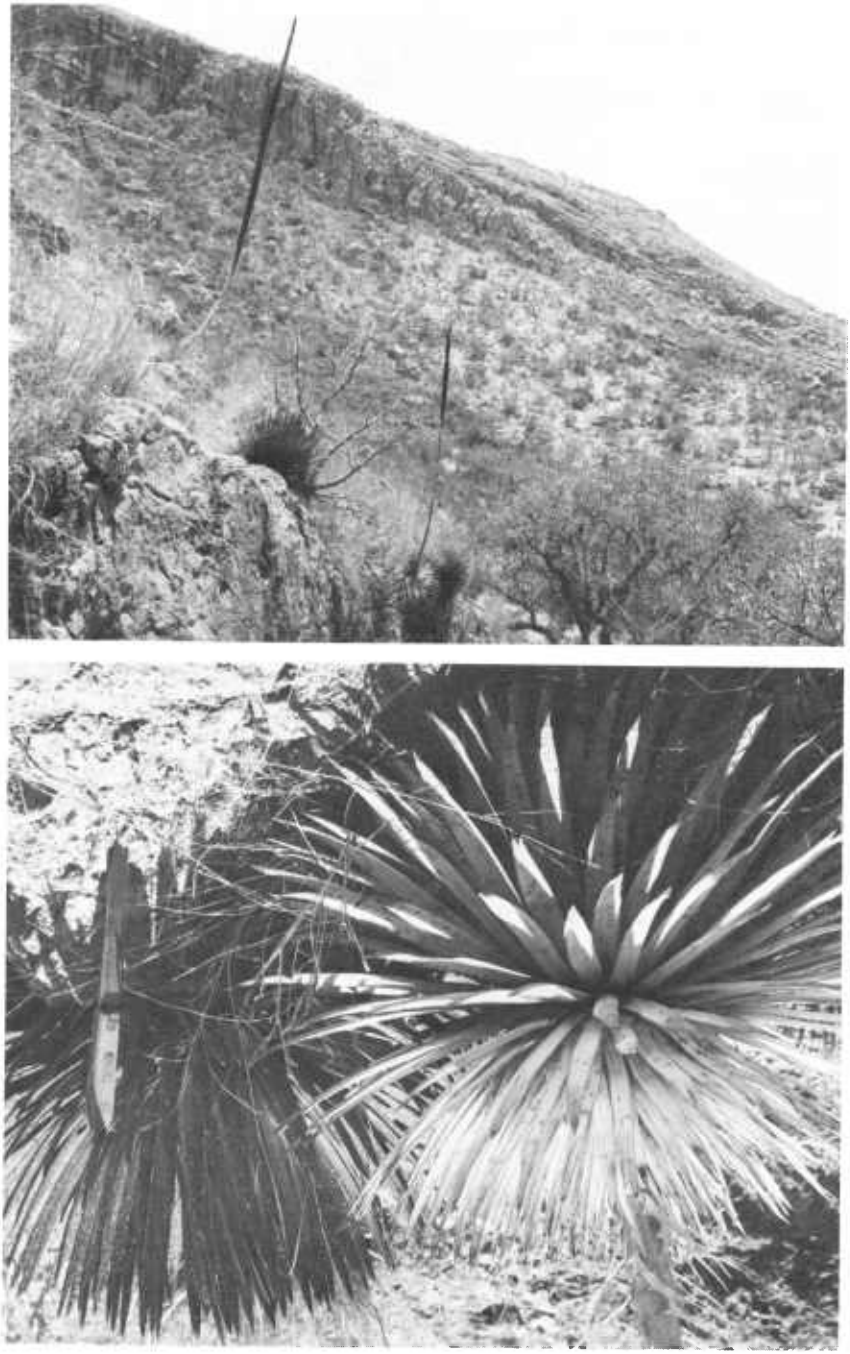


FIGURE 19.—*Agave ocahui:* Leaves and spike section × ⅓; flower pair × 1; flower section slightly enlarged; cuticular pattern × 20. Drawn from Gentry 16637.

recurved and weeping; 6–8 miles northeast of Matapé, Sierra Batuc, *Gentry & Arguelles 16607* (live pl. & seed); about 4 miles west of Sahuaripa, alt. about 1,500-1,800 feet on volcanic rocks, *Gentry & Arguelles 16612* (live pl.); Sierra Murrieta, 15 miles west of Bacanora, in Oak Woodland, alt. about 4,500 feet, May 17, 1957, *Gentry & Arguelles 16626;* southern rim of Canyon Cruz de Peñasco, 7 miles east of Rio Bavispe along road to Bacadéhuachi, alt. about 3,650 feet, June 5, 1960, *Felger 3301* (lf., fl., & cap.), "Lvs. green with white margin; fls. yellow; inflo. ca. 8 ft. tall." *A. ocahui* is known only in northeastern Sonora, where it occurs on cliffs and other outcrops of volcanic rocks at elevations between 1,500 and 4,500 feet. Also noted as "scattered on limestone crest of the Murrieta Mountain" (Gentry notes). Such sites commonly have dry, poor soils inhibiting growth. Plants found on deeper soils and in partial tree shade develop longer, more pliant leaves. (Figs. 20 and 21.)

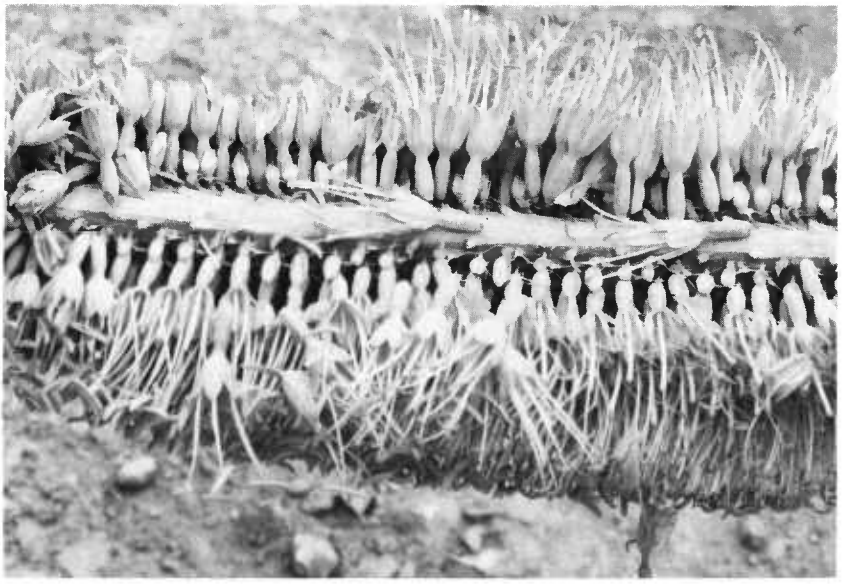
The smooth, narrow leaves with fine, brown, unarmed margins, the prolifically flowering spike with its small, slender, yellow flowers with shallow tube, and the high insertion of filaments, all relate this species with the other Sonoran amoles, *A. vilmoriniana* and *A. chrysoglossa.* The leaves and flowers of *A. ocahui* were found to contain 0.5–1.0 percent smilagenin, which also relates it to the amoles. It is easily distinguished from the others by its small rosette with more numerous, but smaller leaves and by its smaller flowers with small stamens on long filaments. Also, in contrast to the other Sonoran amoles that have fine, weak leaf fibers, the leaf fiber of *A. ocahui* is coarse, abundant, strong, and employed locally for cordage and brushes.

Neither the chemistry nor the fibers of *A. ocahui* were assayed sufficiently to assess the prospects of this plant as a potential resource. Considering the fiber-sapogenin industry of the cultivated, but frost-susceptible fiber agaves, *A. ocahui,* because of its apparent cold hardiness, its superior fibers, and good genin content, merits investigation for cultivation in the United States. The length of generation is not known, nor are its cultural requirements except as generally apply to agaves. It seeds abundantly and all the plants observed in the several populations visited were nonsurculose and showed relatively little variation. The considerable variation in size of rosette and leaf length appeared correlative to site situations. The small plants in the Murrieta collection have grown very slowly since they were planted in 1957. The generative period is probably very long. The flowering season is not definitely known. Although the type plant was flowering in May,



PN-2124, PN-2125

FIGURE 20.—*Agave ocahui:* On tuffaceous rocks on sun slope of Sierra Baviso, Sonora.



PN-2126

FIGURE 21.—*Agave ocahui:* Section of flowering spike on volcanic rocks above Guasabas, Sonora.

repeated visits to other populations during May, June, September, and December found no flowering. (Fig. 20.)

"Ocahui," "ojajui," and "amoliyo" are local names for this agave. The first two terms are of Indian origin and signify fiber or cordage. A related term "majahui" carries the same meaning and is used by country people in Sinaloa and southeastward, but it is applied to such bast fibers as those from the Malvaceae and Sterculiaceae and to *Ceiba.*

***Agave pelona* Gentry, sp. nov.** **Figure 22**

Acaulescent, single, dark green to purplish, shiny, multileaved, toothless, compact rosettes 40–50 cm. tall, 50–80 cm. broad; leaves

Planta monocarpica, acaulescens, 40–50 cm. alta, 50–80 cm. lata; foliis 35–50 × 3–4.5 cm., lineari-lanceolatis, longi-acuminatis, rigidis, margine inermo, albo, firmo, 2 mm. lato; spina terminali valida, alba, 4–7 cm. longa, supra plana, vel canaliculata infra angulata; inflorescentia racemosa, scapo incluso 2–3 m. alta, 12–15 cm. lata; bracteis filamentosis; floribus rubidis, 45–50 mm. longis, longi-pedicellatis; ovario cylindrico, viridi, apice incluso ca. 20 mm. longo; tubo 8–9 mm. longo, 17 mm. lato, infundibuliformi; segmentis subaequalibus, 18 mm. longis, 8–10 mm. latis, relexis, apiculatis; filamentis 35–40 mm. longis, rubris ad apicem tubi insertis; antheris rubris, 15–17 mm. longis, capsulis 25–30 mm. longis, 12–15 mm. latis, oblongis, valvulis tenuibus; seminibus 4 × 4 vel 5 × 5 mm., rugosis, nigris.

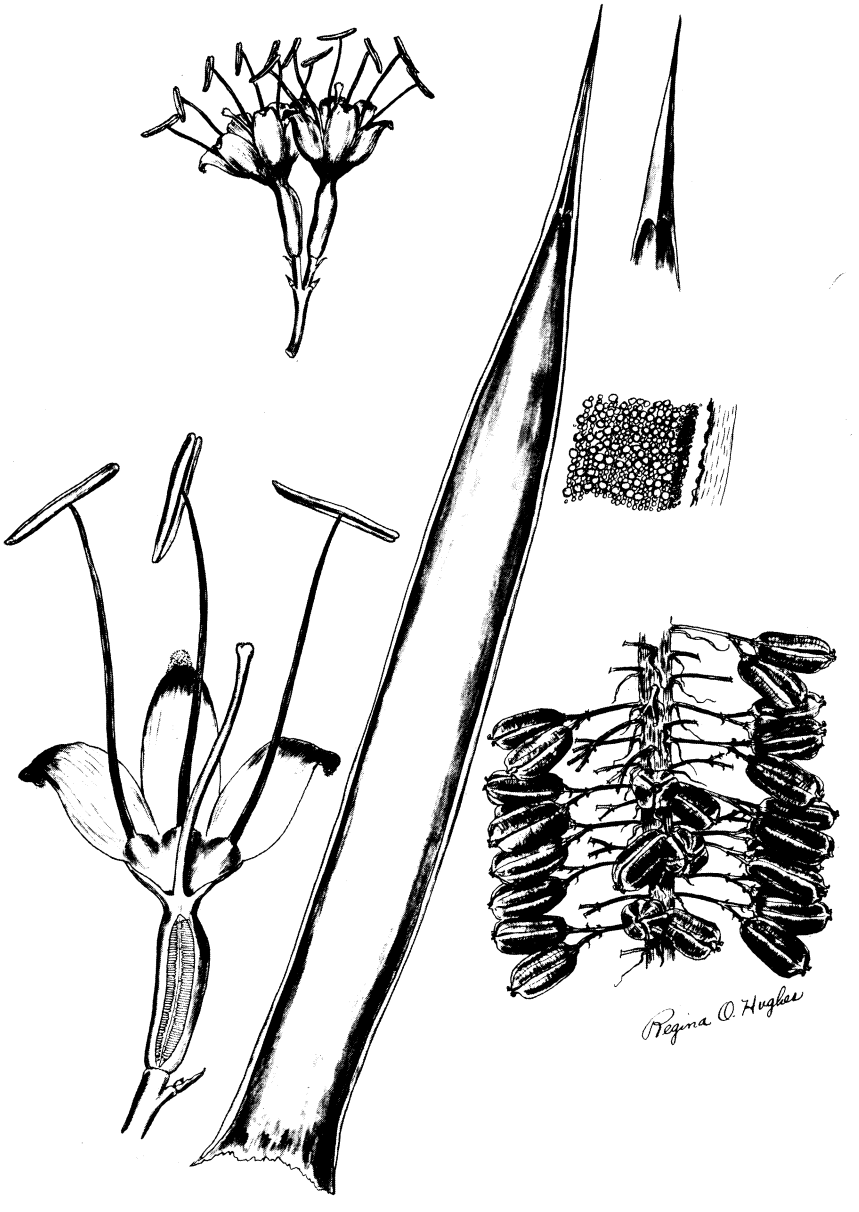
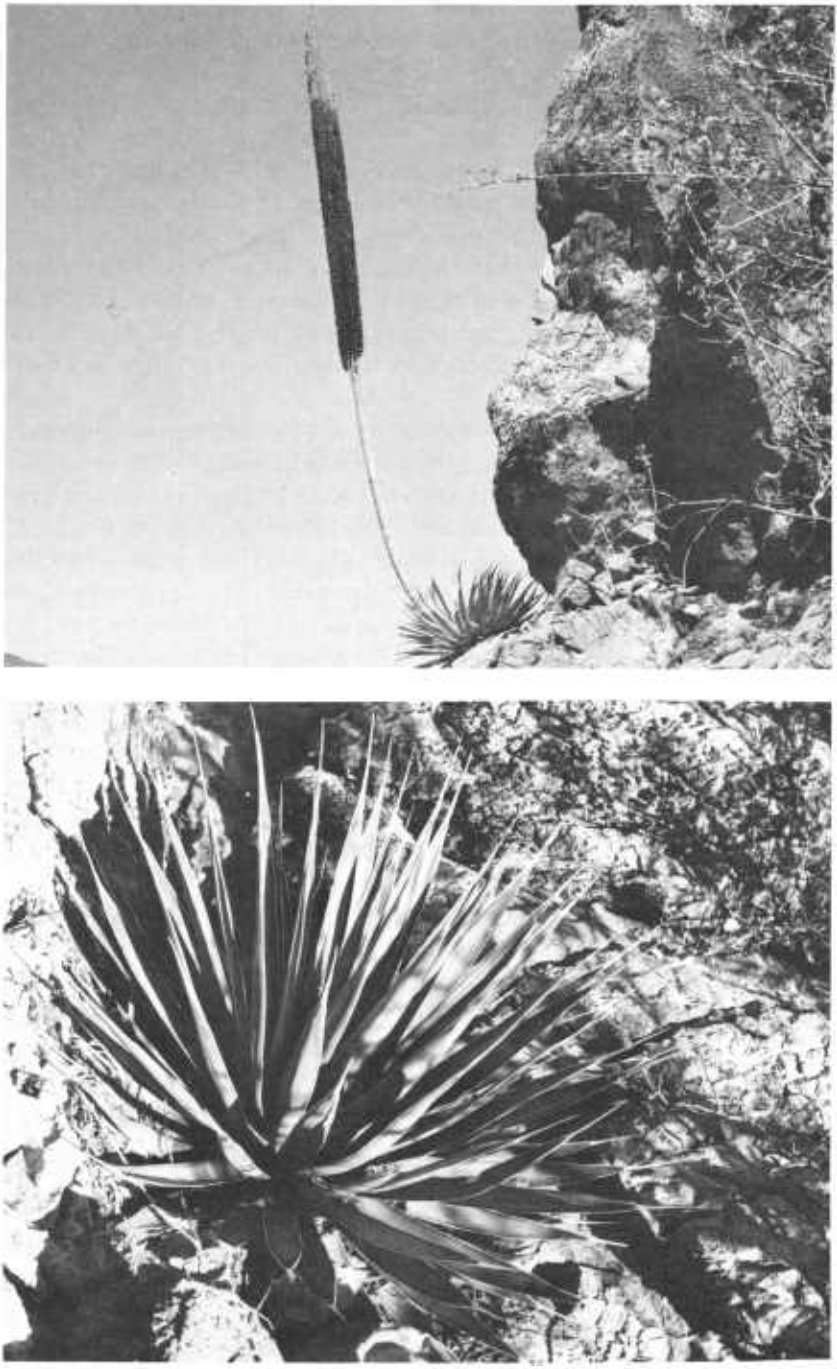


FIGURE 22.—*Agave pelona:* Leaf with spine offset of ventral side, flower pair, and capsules × ½; flower section slightly enlarged with apex of central tepal raised; section of leaf cuticle and margin greatly enlarged. Drawn from Gentry 19898.

35–50 × 3–4.5 cm., linear-lanceolate, long acuminate, sometimes slightly narrowed towards the base, nearly plane above, rounded below, thick, stiff, erect to ascending, shiny dark green, turning reddish to purplish with drought or maturity; epidermis smooth, waxy, minutely circle-punctate; margin toothless, with a narrow, smooth, white, firm border becoming brittle and detachable on dried specimens; spine strong, sharp, 4–7 cm. long, white to reddish, sharply angled below, grooved or plane above, decurrent as a white border down the leaf; inflorescence racemose, 2–3 m. tall, flowering through upper half of shaft; flowers 45–50 mm. long, dark red, campanulate, on bifurcate pedicels 30–40 mm. long; ovary including neck about 20 mm. long, cylindric, slender, light green, faintly striate; tube 8–9 mm. long, 17 mm. wide, openly funnelform, lined with a nectariferous disk; tepals 18 mm. long, 8–10 mm. wide, linear-ovate, plane and unkeeled, the inner widest, 8–9 nerved, recurved at the tip; tip apiculate, white-pappillate; filaments 35–40 mm. long, red, inserted on rim of tube; anthers red, 15–17 mm. long, centrally affixed; pistil small; capsules 25–30 mm. long, 12–15 mm. broad, oblong, light pruinose, thin-walled, rounded and short-apiculate; seeds irregular in size and shape, mostly 4 × 4 to 5 × 5 mm., thick, rugose, sooty black, numerous.

Type—*Gentry & Arguelles 19898,* Cerro Quituni, about 26 miles south of Caborca, Sonora, April 7, 1963, on arid limestone mountain, alt. 1,500-3,000 feet, deposited in U.S. Natl. Herbarium, No. 2549712 and No. 2549713. Also on Cerro Quituni, May 20, 1966, *Barclay & Arguelles 2023* (lf.). SONORA: Cerro del Viejo, about 25 miles south of Caborca, alt. 3,500-4,000 feet, April 5, 1963, *Gentry & Arguelles 19896* (moth-eaten buds) and Feb. 25, 1951, *Gentry 10202* (lf.); Sierrita de Lopez, about 35 miles northwest of Hermosillo, Feb. 19, 1952, *Gentry 11615* (lf.). It was reported by miners to grow on Sierra del Humo, but this is doubtful. The largest population known grows on the precipitous limestone heights of the 25-mile-long Sierra (or Cerro) del Viejo. (Fig. 23.)

This beautiful and distinct, endemic xerophyte has no close relative. The rosettes cling firmly to the rough limestone rocks and cliffs. The rigid, dark-green leaves, often tinged brightly with red and purple, are strikingly outlined by the white, smooth margins and the long, strong, white spine. The long-pedicellate, dark-red flowers with spreading recurved tepals are distinct in the genus. The funnelform tube with its thickened, nectareous inner lining with 6-pointed apex of filaments is like the section *Filiferae,* but the leaf is more like agaves of the amole group or the section Marginatae. However, both leaf and inflorescence of *A. pelona*



PN–2127, PN–2128

FIGURE 23.—*Agave pelona: Upper,* old dry plant with seeded spike; *lower,* live growing rosette in natural habitat on Sierra del Viejo.

show some similarities to *A. utahensis*. One tooth on one leaf was observed on one plant.

Flowering appears to be normally during April, but in dry years flowering is sparce, or not at all. In the dry spring of 1963, all of the several inflorescences found on Sierra del Viejo had the buds completely gutted by an insect, assumed to be a Lepidopteran larva. The flowers on the one flowering plant found on Cerro Quituni the same season were being eaten by a rodent. Several of the buds were collected and placed in a small water jar. These opened the following day and it is from these that my flower measurements and description and Regina Hughes' drawings are taken.

I was first guided to this agave by a "mescalero" encountered along the streets of Caborca, who called this plant "mescal pelon," in reference to the bald or toothless leaf margins. He stated that it was a sweet kind and suitable for making the "moonshine" called "mescal," except its "cabezas" (heads) were too small for the labor involved in cutting and trimming. For this reason, he preferred the larger "mescal lechuguilla" in the same region, described on page 126 as *A. zebra*. The mescaleros of Mexico have frequently been very helpful in my investigations of agaves. Presumably, *A. pelona* was formerly eaten and its strong fibers were used by the local Amerindians, such as the Papagos and Seris who still inhabit adjacent areas, but there are no reports of uses other than those I have already given. Analyses of the leaves for steroids showed 0.06 percent sapogenin from Sierra del Viejo and 0.3 percent smilagenin from Sierrita de Lopez.

For the dry, rocky, succulent gardens of the Southwest, *A. pelona* should make an attractive addition, but should be placed where children cannot fall against its strong, stiff spines. Both leaves and flowers are strongly colored. The lifespan is not known, but must be many years.

For distribution of the Amolae group of agaves, see figure 24.

Subgenus *Agave*

Agave americana L., var. *expansa* (Jacobi) Gentry, stat. nov.

Agave expansa **Jacobi, Nachtrage I in Abh. Schles. Ges. Vaterl. Cult., Abth. Naturwiss. 1868: 151. 1868.**

Large, light-gray rosettes, 1.5–2 m. tall, 2 m. broad, with a short trunk in age, suckering abundantly from early age; leaves 12–15 dm. long, 18–24 cm. wide, lanceolate to spatulate, rather abruptly acuminate, narrowed towards the base, deeply rounded

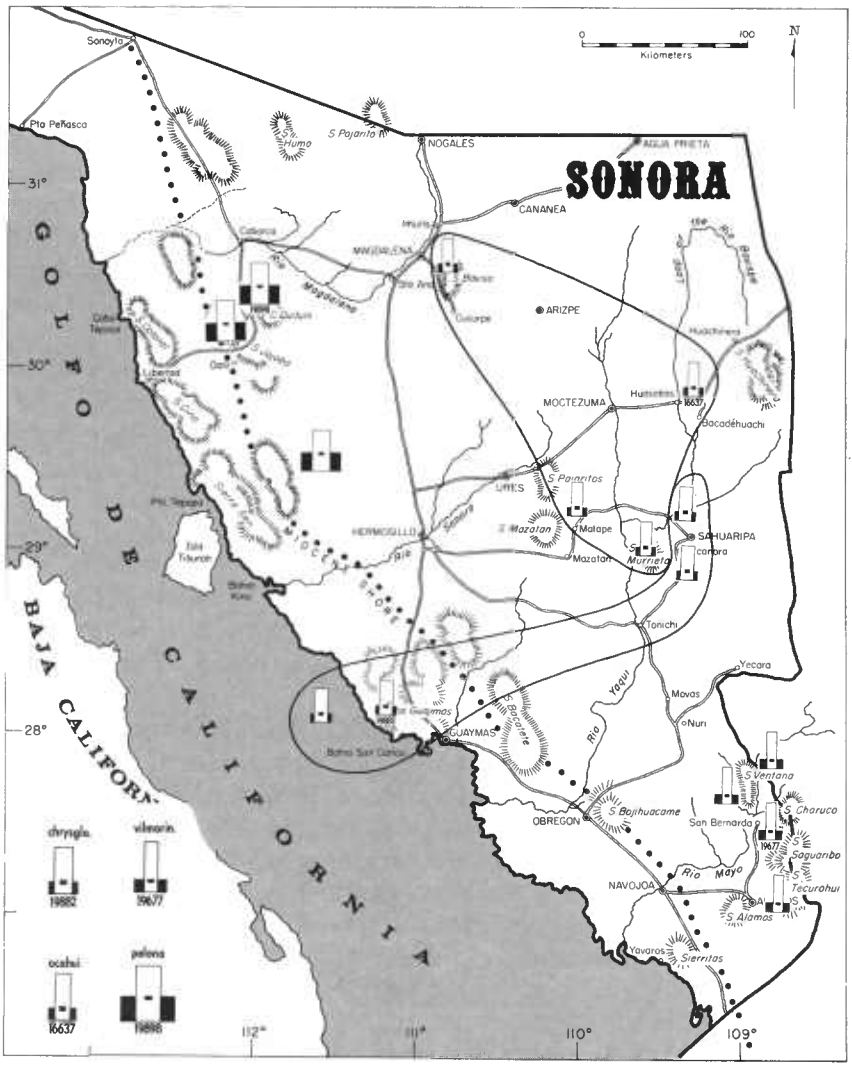


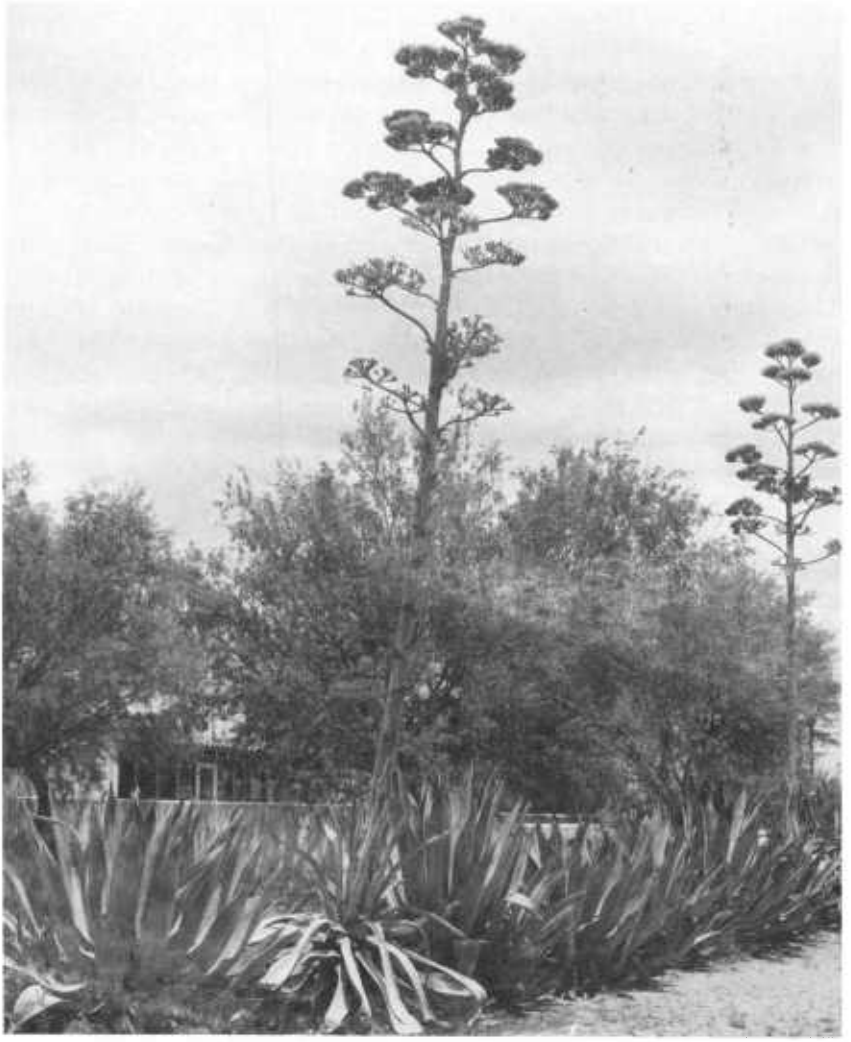
FIGURE 24.—Distribution of the Amolae group of agaves in Sonora, represented by their ideographs. Ideographs with numbers indicate flower collection at the locality occupied. (See p. 37.)

below, the upper ⅔ of leaf more plane, firm, thick, erect or ascending, frequently cross-zoned, sometimes valleculate, the margin nearly straight, usually with several sharply angled, low teats in the midblade; the larger teeth 5–8 mm. high, 1–4 cm. apart, shortly cuspidate from low broad bases, brown becoming gray; spine short, conical, 2–3 cm. long, narrowly grooved above, brown to gray; panicle large, 7–9 m. tall, deeply oval in outline, with 20–

30 long, horizontal laterals; bracts of the peduncle 10–15 cm. long, triangular, chartaceous, reflexed; flowers thick and fleshy, 70–85 mm. long; ovary green, short, tapering from unconstricted neck; tube green, 13–14 mm. deep, 12–20 mm. broad, scarcely bulging, but deeply grooved and thick-walled; tepals pale yellow, erect, thick, 26–32 mm. long, 7–9 mm. broad, linear, involute, cuculate, the outer 2–3 mm. longer, the inner with thick keel, 2 strong costae within, and thin involute margin; filaments stout 65–70 mm. long, flattened on adaxial side and bowed towards pistil, inserted 8–9 mm. above tube base; anthers yellow, 28–32 mm. long, excentric; capsules and seeds not seen.

This variety is known only as a cultivar, introduced in western Europe, where it was described by Jacobi as growing at "St. Germain en Laye bei Paris," France. What is taken for this taxon has been observed from southwestern United States to Jalisco, where it probably originated. It was collected at Amado, Ariz., along the route to Nogales, July 23, 1966, *Gentry & Weber 21983*, from which the present flower description is drawn (fig. 25), Tumacacori, Ariz., Nov. 6, 1950, *Gentry & Ogden 9940* (lf.). SONORA: Rancho Monte Carlo, about 30 miles west of Hermosillo, *Gentry 11631* (lf. for analysis). It has been observed around the Sonoran towns, Nogales and Hermosillo.

It has taken botanists a century since this plant was first described to collect and describe the flowers, a rather shocking delinquency because the plant flowers in both the Mediterranean and the Southwestern United States regions almost every year. Wiggins (*42*) treats *A. expansa* as a synonym of *A. americana*. Indeed, the large, glaucous gray, prolifically suckering rosettes and tall, diffuse panicle resemble the type of the species and genus in its Mediterranean form. Trelease (*43*) regarded the Arizona form as a separate species, distinguishable by its short, heavy, conic spine and unreflexed leaves vs. the long subulate spine and reflexed leaves of *A. americana*. Until 1963 only a few, incomplete herbarium specimens of *A. americana* were available in American herbaria and only two leaf specimens and one poor, withered flower collection of *A. expansa*. The recent flower collection (Gentry & Weber 21983) confirms the close relationship of *A. expansa* to *A. americana*. The flowers of *A. americana*, both in typical form and in the numerous variants found wild and cultivated in northeastern Mexico, are characterized by: a short, tapering ovary, shorter than the perianth; large, thick-fleshy, elongate outer tepals; smaller inner tepals with thick keels, thin involute margins, and paired prominent inner costae; and long, strong filaments



PN–2129

FIGURE 25.—*Agave americana expansa* at Amado, Ariz., as ornamental hedge, well developed with irrigation. Source of Gentry & Weber 21983.

divergent above the tepals. The species forms a highly varied complex, both in flowers and leaves, as represented in wild and cultivated populations of Mexico. The western relative is treated here as a cultivated variety.

The origin of *A. americana* L. has never been known, Linnaeus listing only "America calidiore." (So. Pl. 1: 323, 1753.) A form very close to the Mediterranean form Linnaeus had in mind grows along the lower Rio Grande around Laredo. South of there, in

eastern Mexico, are several variant forms in cultivation. I suspect that some port like the Rio Soto la Marina in northern Tamaulipas, which was among the earliest sheltered harbors along the eastern Agave coast, may well have been the source area of *A. americana*. The Portuguese carried *A. americana* to the Azores in the 16th century. From the Azores it was carried to Europe (Linnaeus). Although they are not of the European or Laredo clone, the collection of several flowering variants in eastern Mexico during the summer of 1963 greatly expand the dimensions of this species. The polymorphic populations from southeastern Texas to Hidalgo enjoin complex relationships awaiting detailed studies. The maguey or metl-culturing Amerindians apparently collected the fortuitous and attractive larger variants from local wild populations. These they propagated by their sucker offsets and several of these clones have diffused widely during the thousands of years of man's cultivation.

The east Mexican *A. americana americana* appear separable from the west Mexican *A. americana expansa* on the basis of leaf characters, as follows:

Leaves long-acuminate, recurved to reflexed; larger teeth longer than (or as long as) their corneous bases are wide, not on sharply raised teats; spines slender, 3–5 cm. long—var. *americana*

Leaves short-acuminate, straight, erectly ascending; larger teeth shorter than their broad, low, corneous bases are wide, raised on teats, some of which are abruptly angled with leaf edge; spines short, thick, conical, 2–3 cm. long—var. *expansa*

Some of the varieties of *A. americana* in Jalisco are used for pulque and as fence plants; one of these, *A. abrupta* Trel., is a form with a thick, short spine on a valleculate short-acuminate leaf. In Sonora, *A. americana expansa* has only desultory use as an ornamental. The indigenous peoples there did not drink pulque. It's sporadic occurrence in and about the modern towns and its scarcity in older Indian villages indicate that *A. americana expansa* was brought northward to Sonora, Arizona, and California in modern times, probably after 1850. It is very common now in southern Arizona and California, where it is used as an ornamental, as a hedge plant, and for holding soil on banks. However, its prolific suckering makes it weedy and the untended bunches become untidy and troublesome in time. If the suckers are controlled, it makes a good and hardy ornamental in our Southwestern States.

Agave bovicornuta **Gentry, Carnegie Inst. Wash. Pub. 527, p. 92. 1942. Figure 26**

Medium to large, single, nonsuckering, light green rosettes, 8–10 dm. tall, 15–20 dm. wide; leaves 60–100 × 14–20 cm., lanceolate

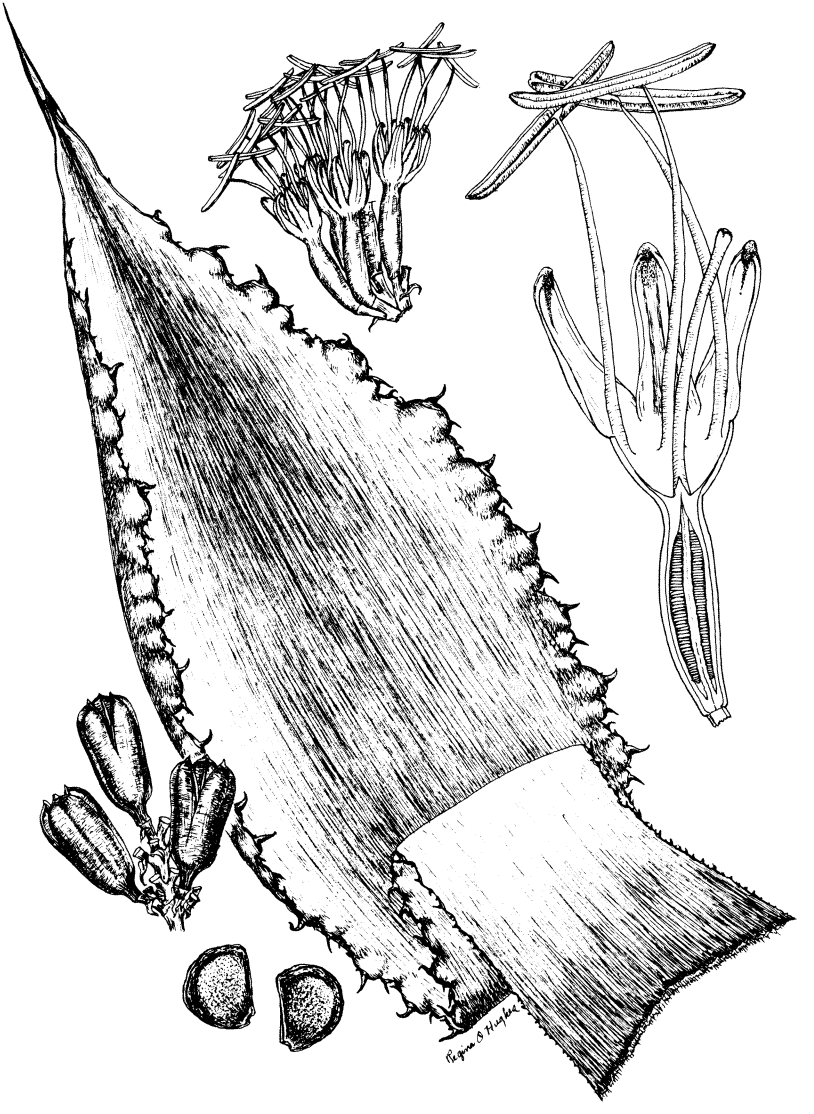
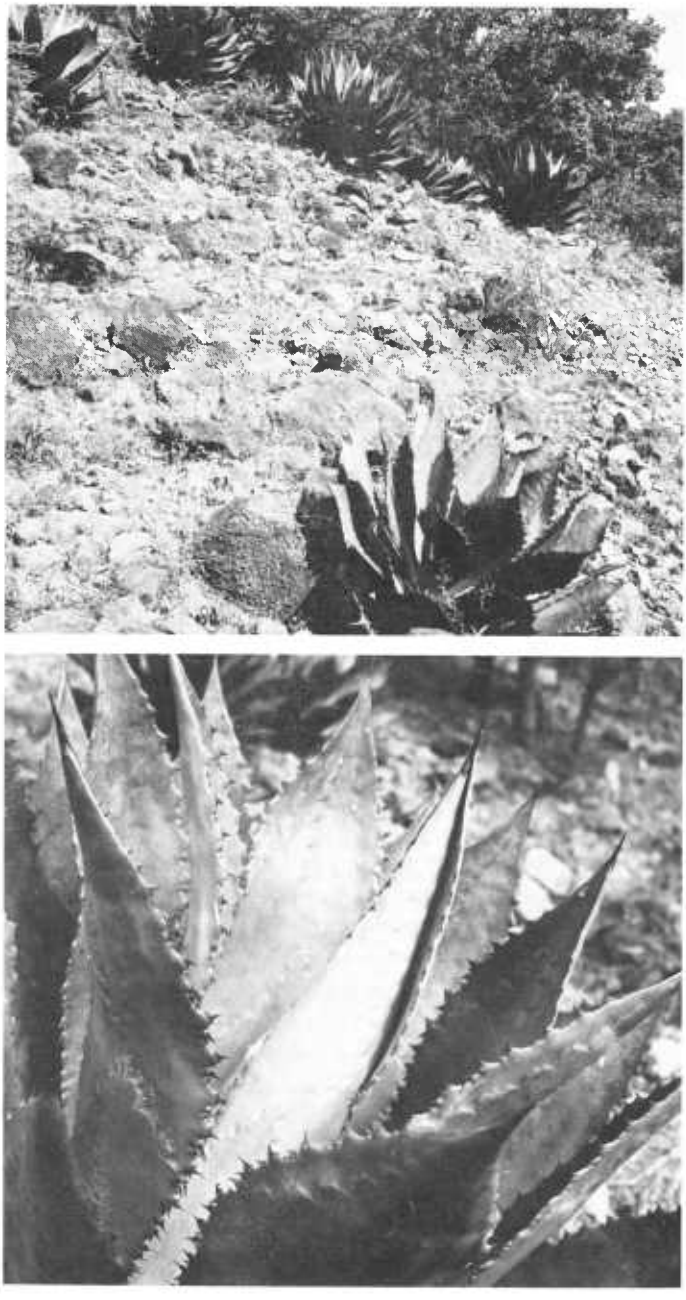


FIGURE 26.—*Agave bovicornuta:* Leaf and flowers drawn from Barclay and Arguelles 2017, the flower section about natural size; capsules × ⅓ and seeds × 1.5 from Gentry 21175.

to spatulate, widest at or above the middle, much narrowed towards the base, yellowish green to green, the younger leaves frequently satiny glaucous, smooth, bud-printed, the margins crenate with prominent teats under the larger teeth; teeth dimorphic, the larger mostly 8–12 mm. long, flexuous and slender above a broad base, mostly 2–4 cm. apart, the smaller mostly 2–5 mm. long, 1-several between the larger, all castaneous or dark brown to grayish brown in age; panicles 5–7 m. tall, narrow and deep with 20–30 short laterals in upper half of shaft; bracts below the laterals 20–30 cm. long, triangular-acuminate, soon drying reflexed, those above smaller; flowers small in compact umbels, greenish yellow, 55–65 mm. long, on pedicels 5–10 mm. long; ovary pale green, 30–35 mm. long including neck 4–6 mm. long; tube 6–8 mm. deep, 12–14 mm. wide; tepals yellow, 18–21 mm. long, 4–6 mm. wide, linear-lanceolate, ascending-spreading, conduplicate, involute, broadly overlapping sinuses, the inner wider and 2-costate within; filaments yellow, 40–45 mm. long, inserted 4–5 mm. above base of tube; anthers 20–23 mm. long, yellow; capsule stipitate, 40–50 mm. long, 15–20 mm. in diameter, oblong, the valves thin; seeds 7×5 mm., finely punctate, the curved side with a flange or wing, the hylar notch shallow.

Type—Curohui, Sierra Saguaribo, Rio Mayo, Apr. 4, 1938, *Gentry 3672*. SONORA: Sierra Tecurahui, Dist. de Alamos, November 1961, *Gentry, Barclay, & Arguelles (photos);* Sierra de Alamos, Mar. 14, 1910, *Rose, Standley, & Russell 12781* (lf., fl., & cap.). La Tinaja, north side of Sierra de Alamos, riparian canyon, Feb. 20, 1954, *Felger 376* (lf. & fl.) "common on rock walls of canyon, flowers bright yellow, only plant found in flower, inflo. to 8 feet"; vicinity of Rancho San Antonio, Sierra Tecurahui, May 20, 1966, *Barclay & Arguelles 2017* (lf. & fl.), "abundant on slopes in pine-oak woods." CHIHUAHUA: High rocky rims around Arroyo Hondo, Sierra Charuco, Mar. 6–7, 1951, *Gentry 10236*. SINALOA: Sierra Surotato, Dec. 13, 1959, *Gentry & Arguelles 18379* (fl. only). Generally it occurs at elevations between 3,000 and 6,000 feet on the rocky open slopes in oak woodland and the pine-oak forest zones. Although common and widespread in the northern Sierra Madre Occidental, the populations are usually local with limited numbers of individuals, and one may travel for many mountain miles without seeing any. (Fig. 27.)

A. bovicornuta is quite clearly of the polymorphic group represented by *A. inaequidens* Koch and several other later names in Berger's sections Scolymoides and Americanae. Trelease and others have used Koch's name, *A. mescal* (1865), for this complex.



PN-2130, PN-2131

FIGURE 27.—*Agave bovicornuta: Upper,* on volcanic rocky open slope in the oak woodland on Sierra Tecurahui, Sonora; *lower,* detail of teeth and bud printing on leaf backs.

However, Berger dropped the taxon and I find Koch never diagnosed it, remarking about it only as a handsome plant observed in two or three gardens. Koch's *A. inaequidens* (1860) appears as the oldest diagnosed name applicable to this group. *A. mescal* should be dropped as a *nomen nudum*. These plants are recognizable by their nonsuckering habit, their yellowish to glaucous green, lanceolate, smooth leaves with crenate margins, their *big teeth on large teats with smaller interstitial teeth,* and their tall, narrow panicles with numerous short, lateral, compact umbels of greenish-yellow flowers. Some individual plants may not have the small interstitial teeth, but all populations observed exhibit them in the majority of individuals. Some teeth arrangements are bizarre, as seen in figure 27, *lower*. The section Crenatae occurs throughout the Sierra Madre Occidental south of the Rio Yaqui watershed and across the trans-Mexican range from Colima to Morelos and if *A. seemanniana* is placed with them, on into Central America. Materials collected to date indicate a large polymorphic group, which with more collections and study may be best systematized as geographic subspecies. For the time being, *A. bovicornuta* as a species is separable from its southern congeners by its small flowers, 45–55 mm. vs. 60–90 mm., and its winter-spring flowering vs. fall flowering.

In Sonora the only species with which *A. bovicornuta* may be confused is *A. wocomahi,* which is also nonsuckering and may show occasional interstitial teeth. However, the leaves of *A. wocomahi* are darker green, not yellowish green, and the teeth are longer and deflexed downward from the mid-blade below. On the basis of flower morphology, I place the two species in separate sections; the tepals of *A. bovicornuta* (section Crenatae) are twice as long as the relatively short tube, whereas the tepals of *A. wocomahi* (section Ditepalae) are about equal to the deep tube in larger flowers, 70–85 mm. long; compare respective ideographs; fig. 4, *B,* page 39. Although flowers are seldom available for field identifications, they are very helpful in separating the species when they are available. These species live sympatrically with *A. shrevei,* and no morphological intergrades have been observed that indicate hybridizing.

Some Rio Mayo people may call both *A. bovicornuta* and *A. wocomahi* "lechuguilla verde," but the mescal makers and the Indians differentiate between the two and call the latter "wocomahi." *A. wocomahi* is employed for distilling the drink mescal and is also eaten, whereas *A. bovicornuta* is usually employed for neither. The latter is probably one of the agaves reported by Ben-

nett and Zingg (*4*) and again by Pennington (*38*) as used for poisoning fish. The juice is caustic and produces a temporary dermatitis on tender skin, with a burning sensation, inflammation, and white welts or blisters. Some people are more susceptible than others. Washing with soap only increases the burning. It is better to wipe dry or wash with clear water only. *A. bovicornuta* was among many samples of section Crenatae analyzed for sapogenins; like the others, it contained little or no sapogenin. The constituents toxic to fish and skin have not been identified chemically. On the Sierra Surotato, Sinaloa, I was given the name "noriba" for *A. bovicornuta.*

A. bovicornuta forms a handsome plant in the succulent garden, especially the more glaucous individuals, where a satiny sheen appears on the new leaves along with crenulated bud printing. Because they do not sucker or form bulbils and apparently require cross-pollination, garden stocks are exhausted in one generation, 12–18 years, unless new field collections are made. The fertile black seeds germinate readily and can easily be cultured in flats or pots during early stages.

***Agave jaiboli*, sp. nov.** **Figure 28**

Medium-size, single, nonsuckering, green to yellowish green, usually open rosettes, 6–10 dm. tall, 14–20 dm. broad; leaves 60–100 × 8–12 cm. linear to lanceolate, widest at or above the middle, gradually narrowed below, usually straightly ascending to spreading, long acuminate, sometimes incurved, plane to conduplicate, the margins noncorneous or narrowly corneous with the decurrent spine for less than its length; the larger teeth mostly 2–3 cm. apart, on small regular teats, 5–8 mm. long, flexed downwards or upwards, reddish brown, the smaller interstitial teeth 1-several, 1–4 mm. long; terminal spine 3–4 cm. long, subulate, terete, reddish brown, shiny, openly or narrowly grooved in lower ½ to ⅔

Planta non-surculosa 6–10 dm. alta, 14–20 dm. lata; foliis viridibus, 60–100 cm. longis, 8–12 cm. latis, lanceolatibus, rectis-adscendentibus; dentis castaneis, dimorphis, majoris 5–8 mm. longis, flexuosis, in mammae 2–3 cm. distantis, minoris 1–4 mm, longis; spina terminalis 3–4 cm. longa, castanea, subulata, supre canaliculata, teres, decurrenta; inflorescentia paniculata, 6–8 m. alta, diffusa, cum ca. 15 ramii lateralibus; floris parvis, 35–50 mm. longis, gracilis; ovario parvo, fusiformo, 20–30 mm. longo, 8 mm. lato; tubo 4–5 mm. longo, 8 mm. lato; segmentis 15–17 mm. longis, 4–5 mm. latis, linearis, involutis, ad apicem rotundis, galeatis, filamentis 35–40 mm. longis ad medius tubo insertis; antheris luteis, 13–14 mm. longis; capsulis oblongis, 40–50 × 18–20 mm., stipitatis; semini 5 × 7 mm., negris, luteis, marginis alatis.

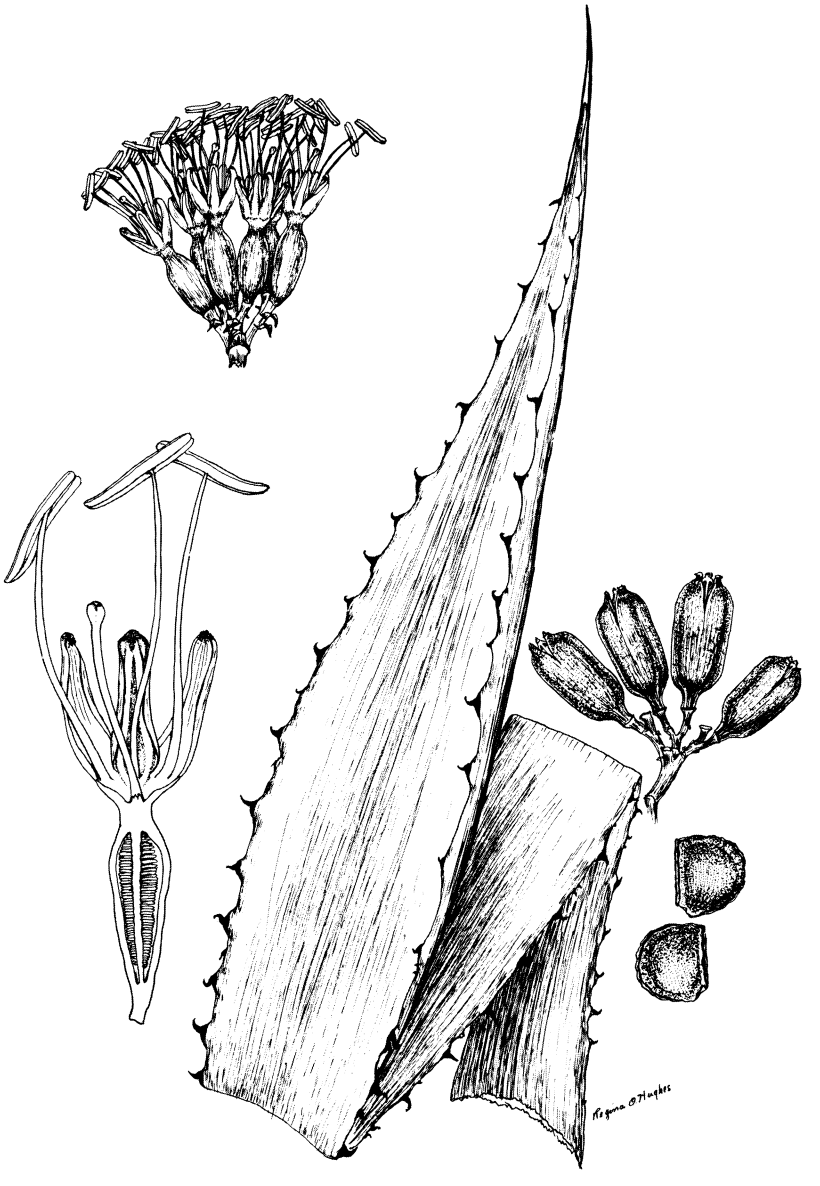


FIGURE 28.—*Agave jaiboli:* Leaf drawn from Arguelles 78; flower cluster and capsules × ⅓, flower section × 1, and seeds × 1½ from Gentry 21177. The flower cluster was reconstructed from old withered flowers persisting on the thickened and still growing ovaries or young fruits.

of length, smooth; panicle 6–8 m. tall, the laterals about 15 in upper ⅓ or ½ of shaft, ascending and rather sigmoid, with small diffuse clusters of flowers on long (1–2 cm.) bifurcate pedicels with discoid apices in fruit; flowers small, slender, 35–50 mm. long; ovary fusiform, 20–30 mm. long including 3–4 mm. neck; tube shallow, 4–5 mm. deep, 8 mm. broad, bulging at filament insertions; tepals yellow, 15–17 mm. long, 4–5 mm. wide, subequal, linear, rounded at tip and glandular floccose, involute, ascending, persisting erect, the outer broader, the inner strongly keeled on back and with 2 prominent ridges within that unite in apex; filaments yellow, 35–40 mm. long; anthers yellow, short 13–14 mm. long (flower description from relaxed dried flowers from inflorescence tip broken off by animal); capsules mostly 40–50 × 18–20 mm., long-stipitate, shortly beaked, light brown; seeds 5 × 7 mm., shiny black, very finely punctate, the straight edge as well as the rounded ones, with a wavy wing.

Type—*Gentry 21177*, Sierra de la Ventana, Rio Mayo, Sonora, Mexico, May 27, 1965, near Sonora-Chihuahua border, in oak-nolina grassland at about 3,500-foot altitude, deposited in U.S. Natl. Herbarium No. 2549714 and No. 2549715. Same locality, *Gentry 21186*, May 28, 1965 (fig. 29). SONORA: 2 miles northwest of Conejos along Arroyo Guajaráy, north of San Bernardo, Dec. 22–25, 1951, *Gentry 11374* (lf. only); near San Bernardo, Rio Mayo, Mar. 8, 1951, *Gentry 10256* (lf. only); vicinity of San Bernardo, May 1959, *Arguelles 78* (lf. only). The species occurs sparsely as widely scattered individuals between 1,500- and 3,500-foot elevations on the more open slopes of the short-tree forest and the grasslands of the lower parts of oak woodland. The open, rocky, grassy slopes in the Guajaráy country appear to be the center of area and habitat (fig. 30). Only one to a dozen or so individuals have been observed in one locality, all as single, non-suckering rosettes. (Figs. 29 and 30.)

The flower structure and dimorphic teeth on the soft, fleshy leaves place *A. jaiboli* in section Crenatae. The narrow, almost ensiform leaves and the small flowers with shallow tubes distinguish this species from its relatives. It is further distinguished from its Sonoran relative *A. bovicornuta* by the unnarrowed haft of the leaves so characteristic of the latter. The natives have no difficulty in separating "jaiboli" or "temeshi," Warihio Indian names, from the unpalatable *A. bovicornuta*. Jaiboli is much esteemed for its sweet edible qualities, so the two species have a quite different chemical makeup. Chemical analyses showed neither of the species to contain appreciable quantities of sapogenins.

PN–2132, PN–2133

FIGURE 29.—*Agave jaiboli* on Sierra de la Ventana: *Left,* tip of panicle was broken off (by a large bird?), caught on oak branches at fall, and provided dried flowers for Gentry 21177; *right,* unusual plant with incurving leaves.

PN–2134

FIGURE 30.—*Agave jaiboli* with budding inflorescence in December near Conejos along Arroyo Guajaráy. Leaf form here is more typical of species than that shown in figure 29.

Both the young flowering shoots and the headlike stem of jaiboli are cooked and eaten by the peoples of the Rio Mayo country; the succulent flowering shoots are usually boiled, the heads pit baked over hot stones and coals. The roving eye of the man with a ready machete is quick to discover a new shoot and it takes but a moment to cut and lay it upon the shoulder to carry home. The species appears to become ever rarer, as it reproduces only by seeds, and my search for flowering specimens has been frustrated during the many years I have known the plant. The non-Indian people, "gente de razon," living on Sierra de la Ventana frequently decapitate the flowering shoots, so the rosette will remain green and mature until such time that it can be conveniently collected for making mescal. This is a common practice in many parts of Mexico.

The young plants are easily cultured and have grown well in my Murrieta collection, showing no ill effects of the 5 to 8 degrees of frost occurring there. However, rabbits and gophers are fond of the plants and completely destroyed three of the plants introduced there. The cottontail rabbit, *Sylvilagus,* ate the leaves of half-grown plants clear down to the base. The food qualities of this plant appear to merit detailed investigation as a potential resource.

For distribution of seven species of the subgenus *Agave,* see figure 31.

Agave desmettiana **Jacobi, Hamburger Garten-Blumenzeitung 22: 217. 1866.** **Figure 32**

Agave regeliana **Jacobi, Hamburger Garten-Blumenzeitung 22: 214. 1866.**

Agave miradorensis **Jacobi, Abh. Schles. Ges. Vaterl. Cult., Abth. Naturwiss. 1868: 147. 1868.**

Medium to small, dark green to glaucous green, symmetrical rosettes 7 × 9 dm., surculose in early years, with graceful arching leaves; leaves 50–60 × 10–12 cm. to 70–80 × 7–9 cm., linear-lanceolate, openly ascending, turgidly brittle, abruptly or gradually narrowed towards the base, the base thicker than wide in cross section, finely and sparsely fibrous, unarmed with smooth unmargined edges or armed with small teeth; teeth 1–2 mm. high, regular, chestnut brown, 1–2 cm. apart or few and irregularly spaced; spine 2–3 cm. long, subulate, dark brown to fuscous, shortly and broadly grooved above; inflorescence paniculate, rather deep and narrow in upper ½ to ⅔ of shaft, 2.5–3 m. tall; bracts

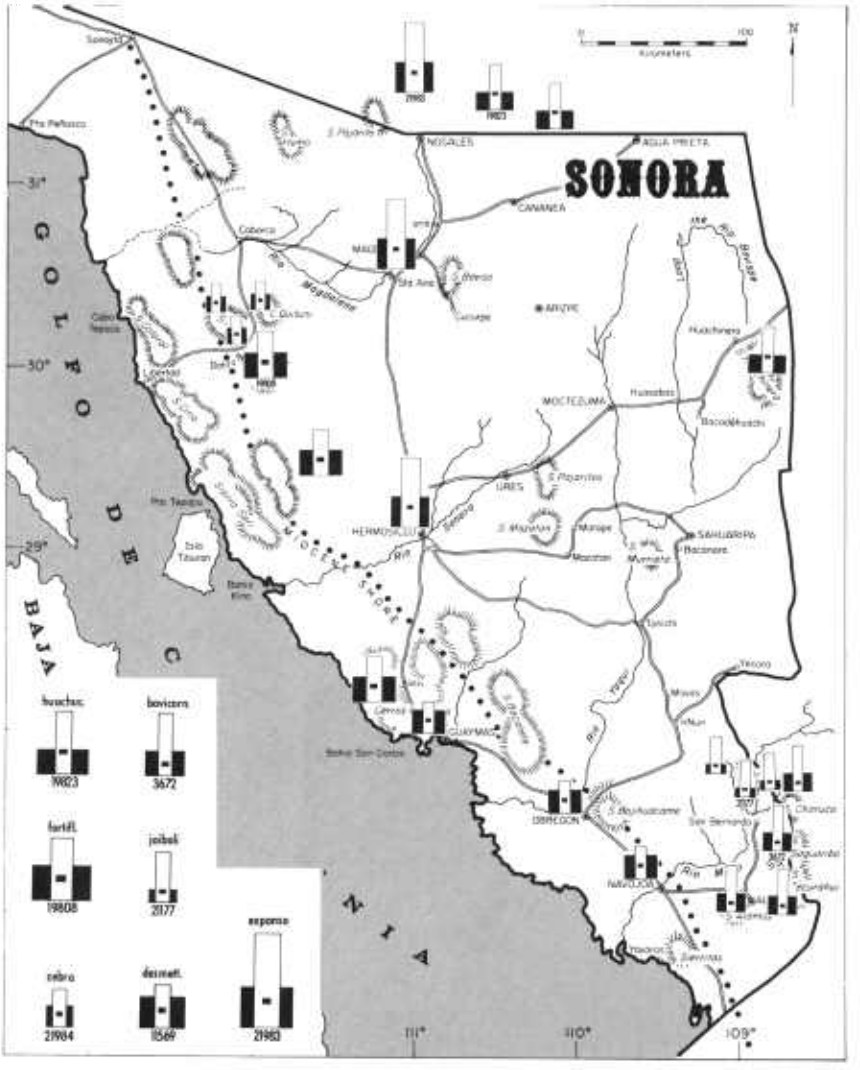


FIGURE 31.—Distribution of 7 species of the subgenus *Agave* in Sonora, represented by their ideographs. Ideographs with numbers indicate flower collection at the locality occupied. (See p. 37.)

short, deltoid; laterals 20–25 with congested umbels of pale yellow flowers about 40 mm. long, on short petiolules subtended by short scarious bracteoles; ovary short-stipitate, small, 12–14 mm. long, green, 6–grooved above, with a very short unconstricted neck; tube 10–12 mm. long, 14 mm. broad, prominently flanged within below inner tepals, deeply grooved and ridged outside; tepals 13–15 mm. long, green in the bud, yellow at anthesis, drying fer-

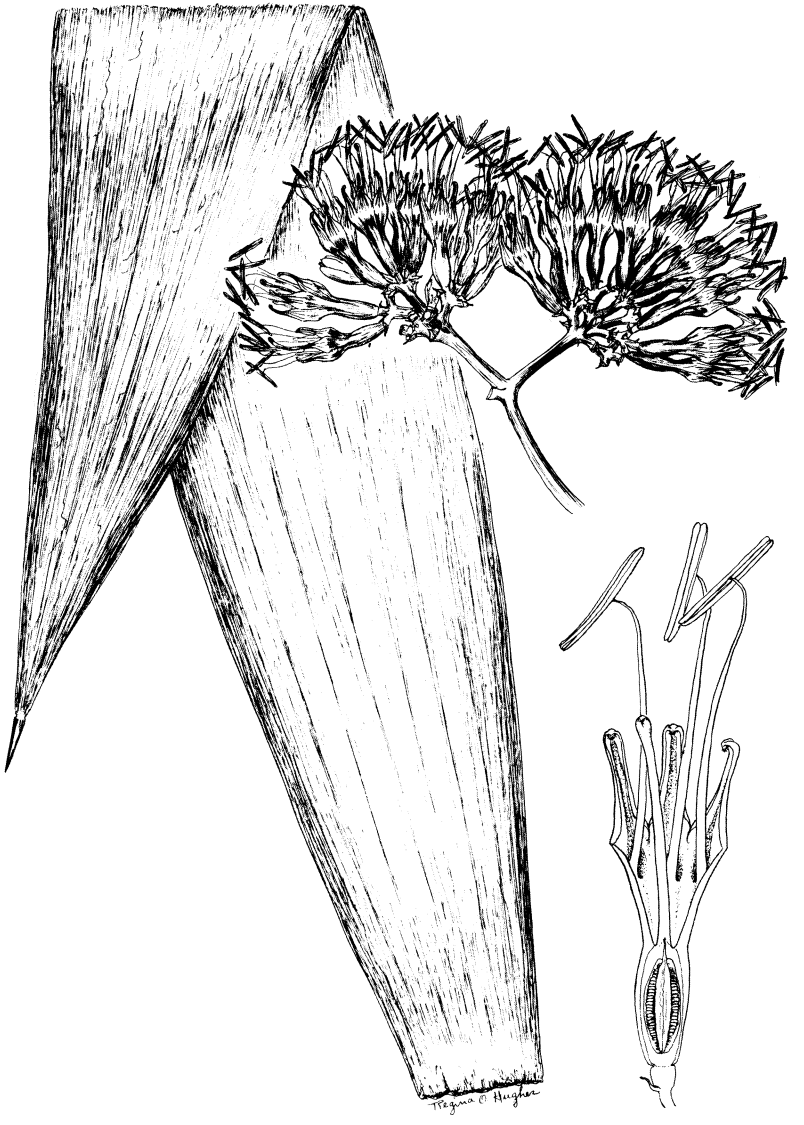


FIGURE 32.—*Agave desmettiana:* Leaf and flower clusters × ⅓; flower section slightly enlarged. Drawn from Gentry 11569.

ruginous, the outer 1 mm. longer than the inner and broadly overlapping at base, the inner sharply involute; filaments 30–35 mm. long, inserted 6–8 mm. above the tube base, yellow; anthers 13–15 mm. long, attached in the middle; capsule and seeds not seen.

Type—Not specified and origin unknown. Syntype—*Gentry 11569,* Guasave, Sinaloa, Mexico, Feb. 8, 1952, cultivated in yard of house (lf. & fl.) (fig. 33). SONORA: Guaymas, Dec. 17, 1951, *Gentry 11359* (live pl. only). TEXAS: Ringold Park, Brownsville, Mar. 14, 1960, *Gentry & Barclay 18411* (lf. & fl.). It has been observed frequently as a cultivated ornamental along the west coast of Mexico from Hermosillo to Mazatlan. Inquiries from several owners along the west coast route in 1952 established the story that it was carried by a peddler 7 or 8 years previously, who sold small plants to housewives. It was subsequently observed as houseplants along the east coast from Tampico northward. Its natural habitat remains unknown, but judging from its tropical, frost-sensitive, delicate leaves, it should be expected in the more humid mountains of Central Mexico. Trelease suggested the Huatusco region of Veracruz as the place of origin (*43,* p. *121.* 1920).

This species is distinguished by its smooth, unarmed, arching leaves, short, compact, paniculate inflorescence, and small flowers with very short ovary and broad, bulging, deeply furrowed tube. The deep exterior furrows are complemented within by conspicuous costae that border the filaments along the inner tepals. These provide structural strength to the thin perianth above the thickened nectariferous tissue of the lower half of the tube. This costate structure is well developed in the section Sisalanae. The present taxon differs from all other members of the section reviewed by its smaller, more graceful rosettes, small dense panicles (vs. tall, diffuse), and smaller flowers (35–40 mm. vs. 60–90 mm.) with a very short, nearly neckless ovary. Like *A. sisalana* and some other members of the section, *A. desmettiana* may have either perfectly smooth leaf margins, or some leaves with small, irregularly spaced teeth, or others with a regular set of small teeth, as in the Ringold Park collection in Brownsville. The nearer relatives include *A. miradorensis* and *A. regeliana,* both described by Jacobi in European collections but which apparently originated from the environs of Mirador in Veracruz, Mexico.

There are no tangible characters in Jacobi's descriptions or in his sketches (reviewed in the U.S. Natl. Herbarium) that distinguish these taxa as species. Berger (*5*) in a footnote under *A. miradorensis* states that it is the same as *A. desmettiana,* which is the priority name. The inflorescence of *A. regeliana* is still unknown, and unless recorded clonal descendants are still available in Europe, it will never be known. The other sectional relatives, including *A. franceschiana* Trel., *A. weberi* Cels, and *A. neglecta* Small, are larger, coarser plants with tall, diffuse panicles and larger flowers, and are all more xerophytic than *A. desmettiana.*

PN-2135

FIGURE 33.—*Agave desmettiana* flowering panicle cut from a cultivated plant at Guasave, Sinaloa.

There appear to be more names than species in this group, but these will be dealt with more comprehensively in a later, more appropriate work. The Desert Nursery near Riverside, Calif., has a fine growing series of this section, with some individuals that appear to be recent introgressive hybrids from local cultivations.

A. desmettiana with its soft, pliant, arching, and frequently glaucous leaves is an attractive ornamental. The glaucous quality and color varies with growing conditions and among individuals. It is, however, sensitive to frost and young plants were killed at Murrieta, Calif. In the Mexican gardens, it grows rapidly when given plenty of water, throws vigorous offsets early in life, and blooms in the early spring within 8 to 10 years. The fiber is fine and weak. The leaves were found to contain mostly negligible amounts of sapogenin, up to 0.3 percent. Except as an ornamental, no local uses were observed or reported for the plant. (Fig. 33.)

***Agave murpheyi* F. Gibson, Boyce Thompson Inst. Contrib. 7: 83, fig. 1. 1935.**

Medium-size, freely suckering by rhizomes, light green, compact rosettes, 60–80 cm. tall, about 1 m. broad, with numerous leaves, spring-blooming but fall-starting; leaves 50–65 × 6–8 cm., linear, short-acuminate, light glaucous green to yellowish green, frequently lightly cross-zoned, firm, straight, bud-printing clear, the margin undulate with small regular teeth 3–4 mm. long, mostly 1–2 cm. apart, bases brown, cusps graying; spines short, 12–20 mm. long, conic, very shortly grooved or flattened above, dark brown becoming grayish; panicle bulbiferous, 3–4 m. tall on a thick shaft with scarious, triangular bracts 10–15 cm. long and 10–15 short, compact laterals in upper ¼ of shaft; flowers pale waxy green with purplish to brownish tips, 65–75 mm. long; ovary thick, rounded, 32–40 mm. long, scarcely narrowed at neck; tube deep, urceolate, 16–20 mm. deep, 15–19 mm. wide, 6-grooved from the tepal sinuses; tepals unequal, the outer longer, 15–19 mm. long, 7 mm. wide in the middle, overlapping the inner, linear, rounded on back, strictly erect, thick, the tip thickly hooded, brownish, the inner strongly keeled, pale yellow; filaments 45–50 mm. long, unequally inserted 8–12 mm. above bottom of tube, yellow; anthers 25–26 mm. long, yellow, slightly excentric: capsules obovate to oblong or ovate, 2–2.5 × 5–6 cm., stipitate, beaked; seeds "dull black, 6 × 9 mm., thin" (loc. cit.).

Type—from near Boyce Thompson Southwestern Arboretum, Superior, Ariz., deposited there and the type clone cultivated. The species is reported to grow near Roosevelt Dam, Tonto Basin, and

PN-2136, PN-2137

FIGURE 34.—*Agave murpheyi* at San Luisito, Sonora. Small off-sets clutter around the base of the flowering plant. The panicle is typically full of bulbils.

Paradise Valley, and along the base of Superstition Mountains, all in central Arizona. The writer also saw it cultivated at Sells, Ariz., and a Papago Indian reported the same had been brought in from the neighboring mountains in view to the southwest of Sells. SONORA: San Luisito, along road to Quitovac from Caborca, Sept. 4, 1965, *Gentry & Arguelles 21204*. Cultivated in a yard, whose owner stated that his plants had been brought from the nearby hills (1–2 miles), where it is wild. He dissuaded me from going there by saying that all the larger plants had been cut for eating or for making mescal. (Fig. 34.)

The flower structure clearly alines this agave with other members of the section Ditepalae. In addition to the separating characters given in the key to the species, I may add here its prolifically bulbiferous inflorescence, which is short, compact, and limited to the top ¼ or ⅓ of the shaft. It blooms much earlier than other agaves in its area. Its habit of starting the flowering shoot in the fall means that the succulent, turgid tissues are resistant to the winter freezes regularly occurring in its habitat. Gibson wrote (loc. cit.): "Inflorescence very strongly bulbiferous, lasting into the second or third year. The bulbs form in the axils of small scaly bracts on the pedicels, from adventitious buds, or from the base of other bulbs." All plants I have seen show relatively little variation and once the species is observed, it is readily recognized again. The plants cultivated at San Luisito have longer leaves with more closely set teeth than the type clone, but the aspect and essential characters of the species are plainly there, including the prolific reproduction with bulbils and rhizomatous offsets. (Fig. 34.)

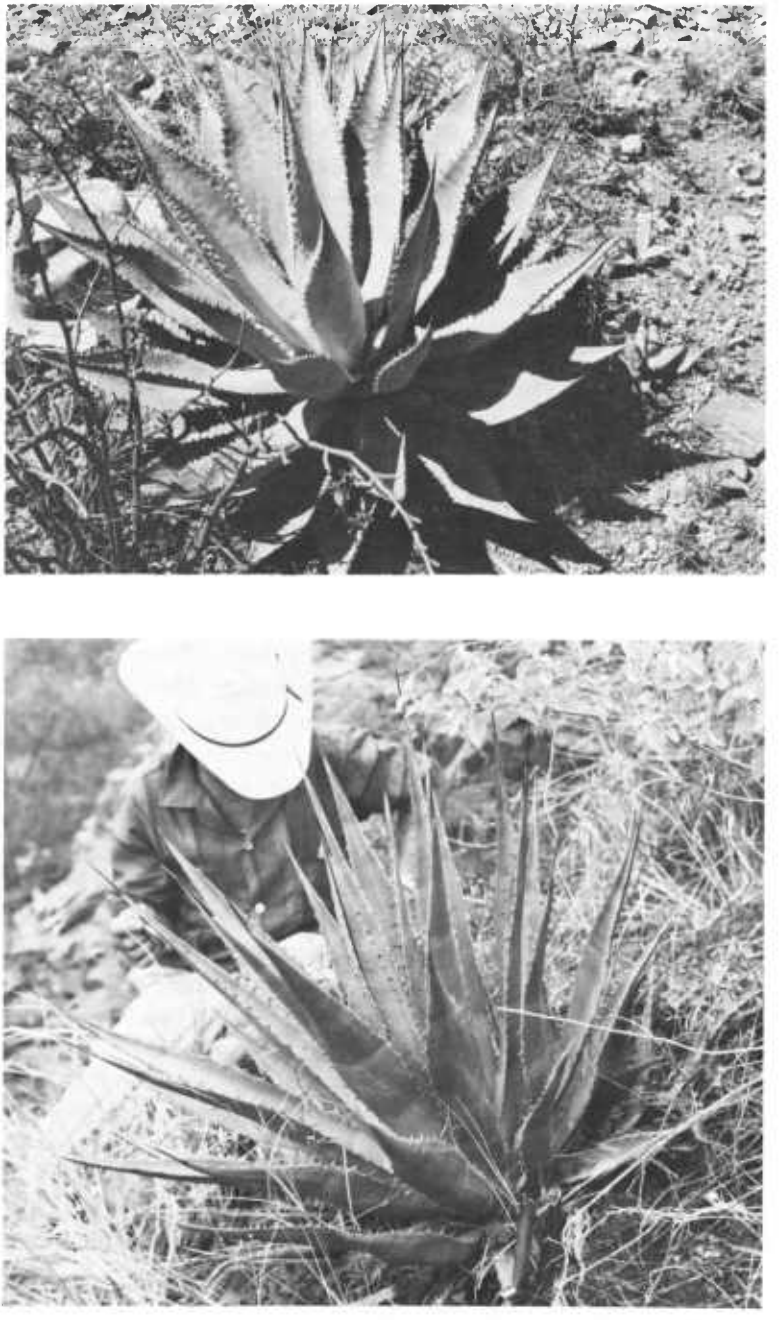
***Agave palmeri* Engelm., Acad. Sci. St. Louis Trans. 3: 313. 1875.**

Rosettes at first single, later suckering, 5–12 dm. tall, 10–12 dm. broad, rather open about the conal bud; leaves mostly 35–75 × 7–10 cm. usually narrowed above the base, lanceolate, long-acuminate, rather rigid, somewhat guttered, thick at base, convex below, pale green to light glaucous green or reddish-tinged, the margins nearly straight or undulate with small teatlike bases under closely set, rather regular, slender teeth, which are variously flexed, smaller teeth sometimes between the larger; spine strong, 3–6 cm. long, shortly and openly grooved above the base, castaneous or brown to aging gray, acicular; panicle deep, broad, open, 3–5 m. tall, with triangular bracts and 8–12 horizontal laterals in upper ⅓ of shaft; flowers 45–55 mm. long, narrow, pale greenish yellow to waxy white, reddish in bud; ovary shiny

green, 25–30 mm. long including short neck; tube 12–14 mm. deep, 10 mm. wide; tepals persistently erect, leathery, yellow to pink below, conspicuously red to brownish on calloused tip, dimorphic, the outer 10–13 mm. long, longer than and overlapping the inner, the inner 2 mm. shorter and narrowly keeled on back; filaments 40–45 mm. long, reddish or pale yellow, inserted midway in tube with those opposite the outer tepals inserted higher than the others; anthers 15–18 mm. long, yellow; capsule oblong to pyriform, 3.5–6 × 1.8–2 cm., the dried walls thick and strong, short to long apiculate; seeds sooty black, 5–7 mm. along the straight edge, 4–5 mm. broad, thin, flat.

Type—Not specified; from Schott, Palmer, & Rothrock who made scattered collections in southeastern Arizona. SONORA: Nogales, June 4, 1897, *Rose 1200* (lf.) ; Arroyo de la Galera (loop of the Bavispe River), July 27, 1940, *White 3049* (lf. & fl.) ; Santa Rosa canyon near Bavispe, July 15, 1938, *White 517* (lf. & fl.) ; 16 miles southeast of Magdalena along road to Cucurpe, April 1963, *Gentry 19888;* Sierra de Pajaritos, about 12 miles east of Ures, Mar. 11, 1951, *Gentry 10274* (lf., cap., & photo) ; mountain above east of Guasabas on volcanics in oak woodland, alt. 4,000 feet, May 21, 1957, *Gentry 16641* (live pl.); 6.3 miles northwest of Nacori Chico, June 10, 1960, *Felger & Marshall 3343* (lf. & buds) "with lower oaks ca. 3,400 feet alt., common, non-suckering"; El Coyote northeast of Moctezuma on north-facing slopes with lower oaks, alt. about 3,400 feet, July 19, 1960, *Felger & Beasly 3525,* "now in full flower—flowers white with callous tip, ovary green"; 16.1 kms. north of Nacozari, oak-grassland, July 22, 1960, *Felger 3595* (lf. & fl.) ; 15.4 miles southeast of Magdalena along road to Cucurpe, alt. about 3,400 feet, July 16, 1960, *Felger 3457* (lf. & fl.) and at 16 miles southeast of Magdalena, *Barclay & Arguelles 2013;* 8.3 miles north of Magdalena, alt. about 3,100 feet, Aug. 19, 1960, *Felger 3781* (lf. & fl.) ; 15 miles north of Fronteras, alt. about 4,100 feet, Sept. 7, 1960, *Felger 4026* (lf. & fl.) ; Sierra del Humo, Dist. Caborca, near Rancho Cimarron, Sept. 3, 1965, *Gentry 21200* (lf., cap., & live pl.). CHIHUAHUA: Near Sierra en Media, plains, Sept. 24–26, 1899, *Nelson 6469* (lf. & fl.), the only collection I have seen from Chihuahua. (Fig. 35, *lower.*)

A. palmeri is a widely scattered but characteristic plant of the oak woodland and grama grassland communities at altitudes between 3,000 and 6,000 feet. It shows good development on the limestone slopes at altitudes between 4,000 and 5,000 feet on the Patagonia Hills and along highway 86 where it passes through the granite of Texas Canyon in Arizona. A smaller form occurs in northern Sonora in somewhat lower elevations on the rocky



PN–2138, PN–2139

FIGURE 35.—*Agave palmeri: Upper,* glaucous form on the lower slope of Sierra Baviso; *lower,* small form on Sierra del Humo.

brush slopes and comprises the western segment of the species. (Fig. 35.)

It flowers mainly in June and July. Hummingbirds, other wild fowl, and many insects visit the flowers. The night visitors are unknown to me. The capsules from the Sierra de Pajaritos show large pustulate scars, probably made by the large, sap-sucking bugs of the family Coreidae observed on the plants. Good black seeds have been collected from wild plants, and progeny are also produced by rhizomatous offsets.

Characteristic of the species are the long lanceolate leaf, typically narrow in its northern range, its close-set, slender teeth, sometimes with smaller ones between, and the reddish tepals about equaling the tube. About the margins of its considerable area it shows what is taken for introgressive variation; on the north in the Ricon Mountains with *A. chrysantha* Peebles, on the south in east central Sonora with *A. shrevei.* I have separated the southern representatives of *A. palmeri* from *A. shrevei* on leaf and flower characters; i.e., the broader leaves and the much deeper tube and relatively shorter tepals of the latter (fig. 4, *A* and *B*). The broad, glaucous green leaves in populations in the Rio Bavispe watershed resemble those of *A. shrevei,* but flowers collected by Felger—*3595, 3525, 3343*—show the smaller flowers with shallower tubes of *A. palmeri* and led me to cite these collections, along with *Gentry 16641,* under this species. An introgressive aspect in these eastern Sonoran populations extends as far south as the upper Guajaráy country.

Peebles (*30*) has given good key characters for separating *A. chrysantha* from *A. palmeri.* Little (*32*) reduced *A. chrysantha* to a variety of *A. palmeri* on the grounds of intergrading characters, but hybridization is much better understood now, and no longer in itself constitutes grounds for combining species. In fact, it can be a measure of their separateness. The scattered population along the main highway in Sonora between Nogales and Magdalena consists of small plants, reflecting the drier and lower elevations. Similar small plants were encountered on the Sierra del Humo (fig. 35) and on the northern slopes of the Baboquivari Mountains, along the grade up Kitt Peak. These populations are apparently *A. palmeri* and perhaps their small apartness should be nominated subspecifically. However, there is insufficient evidence for doing this. They are a small part of a large polymorphic group, including, besides the species mentioned, *A. colorata, A. flexispina,* and other nondesignated forms ranging from central Arizona and New Mexico into Durango, Mexico. There are very

few specimens and far fewer flowers available for studying the systematic problems posed by this group.

In northeastern Sonora, the people called *A. palmeri* "lechuguilla" and said it was collected for eating and for making mescal. It was much used for food, fiber, and beverage by the Indian tribes inhabiting its region. Castetter, Bell and Grove (*8*) report its uses by the Papago, Pima, and Apache Indians. The young, tender, emerging flowering shoots are still eaten by the Mexicans. They are also eaten by cattle, rodents, and other animals. It is among the sweeter kinds with little or no sapogenin reported in assays (*52*) ; 0.5 percent hecogenin was found in the leaves of *Gentry & Ogden 9915,* Pyramid Mountains, New Mexico. Several other assays from plants in other localities were negative.

Agave wocomahi **Gentry, Carnegie Inst. Wash. Pub. 527, p. 96. 1942.** **Figure 36**

Rosettes medium to large, 0.8–1.3 m. tall, 1.5–2 m. broad, nonsuckering, eventually depressed and open at maturity; leaves 30 × 9 cm. to 90 × 25 cm., mostly lanceolate to linear-lanceolate, rarely ovate, somewhat narrowed towards the base, plane, thick-fleshy, rather rigid, ascending to depressed in age, dark green to glaucous green, smooth, the margins straight to undulate with large teeth, 1–2 cm. long, dark brown to glaucous brown, variously flexed, these below the midblade frequently down-flexed, and smaller interstitial teeth irregularly occurring; spine stout, 3–6 cm. long, usually sinuous, flattened or hollowed in a broad groove above, short or long-decurrent; panicle 3–5 m. tall, open, with 8–15 laterals in upper ⅓ of shaft; bracts in the midshaft 15–20 cm. long, scarious, appressed or reflexed; flowers yellow, in small umbels, 65–85 mm. long, erect; ovary cylindrical, 34–40 mm. long including the neck 2–5 mm. long, light green; tube deeply funnelform, 18–22 mm. deep, 15 mm. broad, light yellow, narrowly grooved below the tepal sinuses; tepals dimorphic, 15–23 mm. long, 5 mm. wide, yellow, erect, thick, linear, conduplicate, rounded and deeply hooded at tip, the outer with papillate pubescence well below apex and sometimes red-tipped, the inner shorter and prominently keeled; filaments 60–65 mm. long, inserted unequally 9–14 mm. above base of tube; anthers yellow, large, 26–34 mm. long, eccentric; pistil with a large stigmatic head; capsules short-stipitate, oblong, 50–60 mm. long, 15 mm. or more in diameter; seeds 7 × 4.5–5 mm., shiny black, oblique, flattened on the end opposite the hylar notch, finely punctulate, wavy corrugate, with a narrow margin partly upcurved.

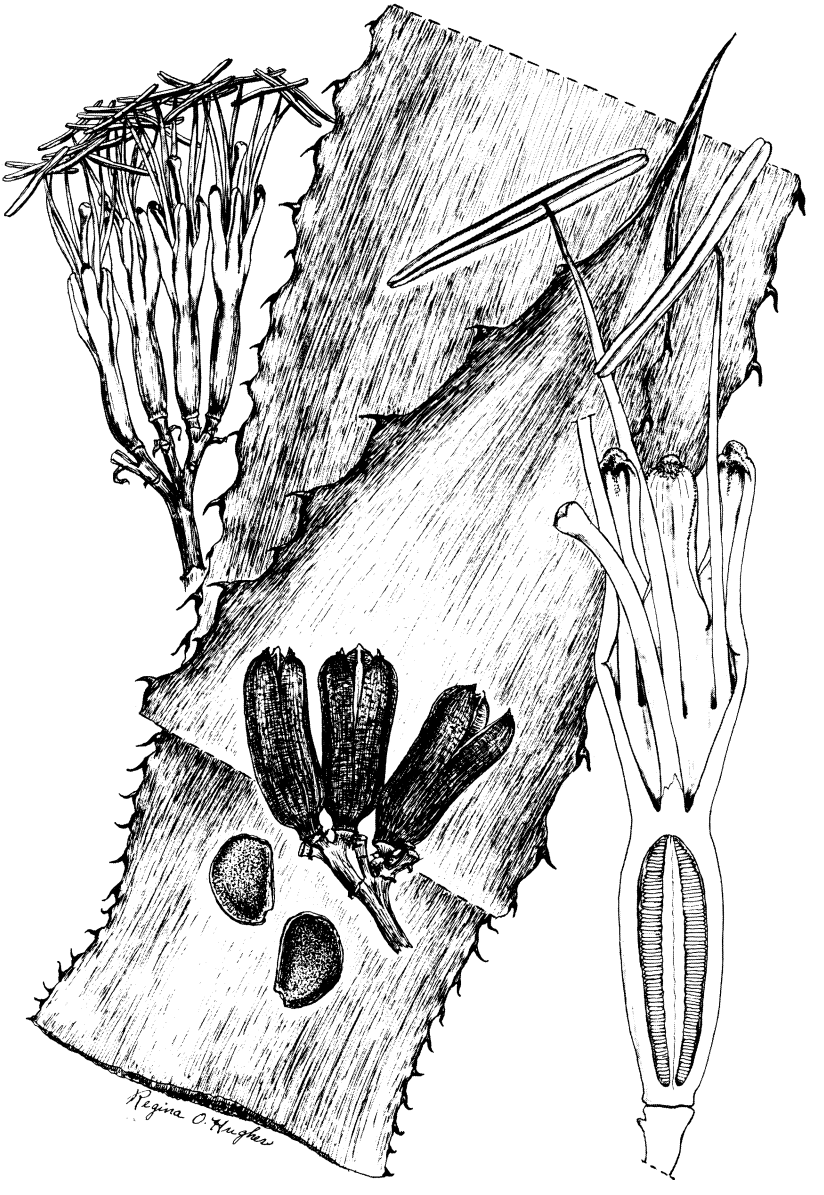


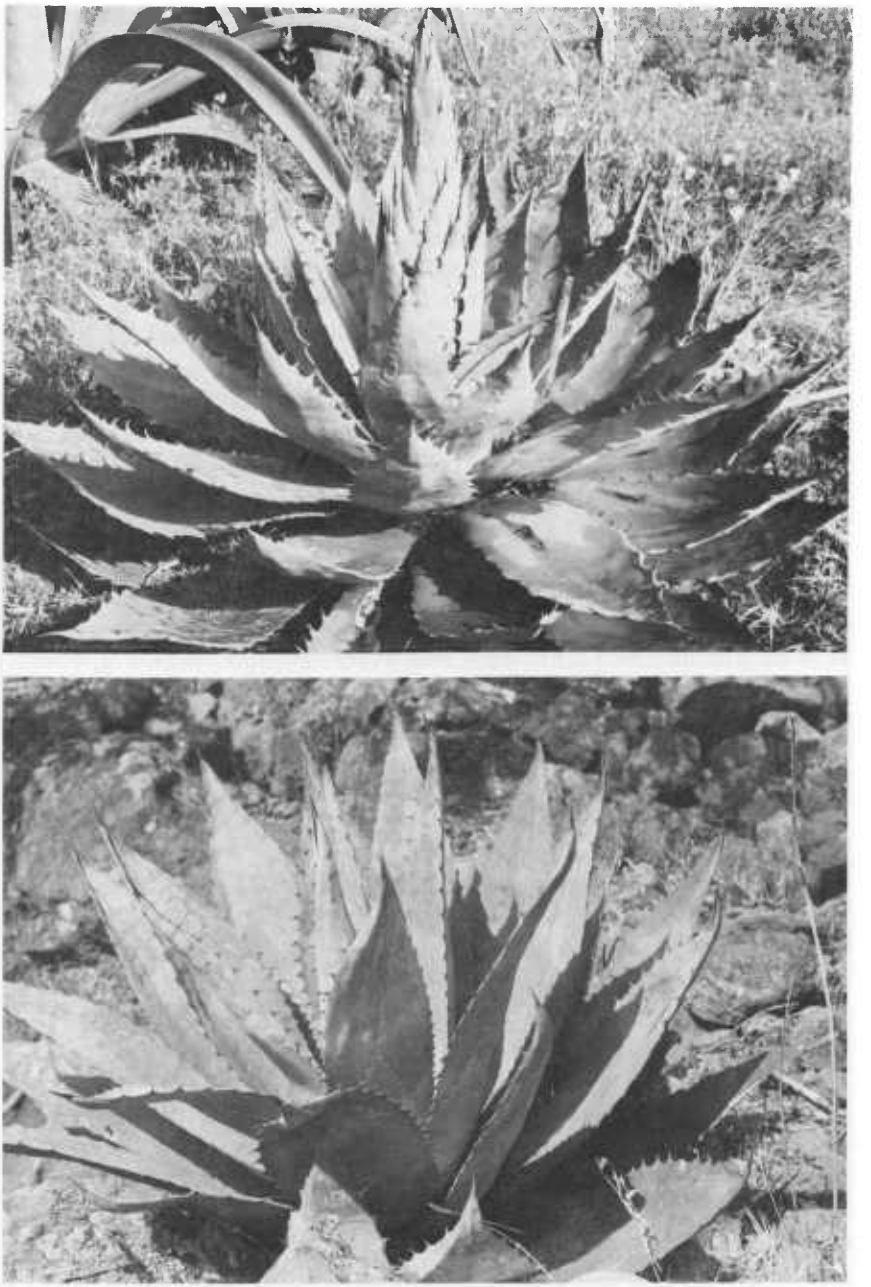
FIGURE 36.—*Agave wocomahi:* Leaf drawn from type, Gentry 1989; flowers from Gentry 10254, cluster × ⅓, flower section slightly enlarged; capsule × ½ and seeds × 2 from Gentry 17666.

Type—Huicorichi, Sierra Huicorichi, Rio Mayo, Chihuahua, Oct. 7, 1935, *Gentry 1989* (fl. & lf.). CHIHUAHUA: same locality as type specimens, *Gentry & Arguelles 11397;* high rocky rims around Arroyo Hondo, Sierra Charuco, Mar. 6–7, 1951, *Gentry & Arguelles 10252, 10254* (flowered at Murrieta, Calif., July 25-Aug. 10, 1962 (fig. 37, *upper*)); Sierra Chinatu, Dist. Guadelupe y Calvo, Oct. 9, 1959, *Gentry, Correll, & Arguelles 17988* (lf.). SONORA: Sierra Charuco, Rio Mayo, Mar. 6, 1951, *Gentry 10225* in part (lf.); Guajaráy Scarp, north of Curopaco and Arroyo Guajaráy, Feb. 13, 1952, *Gentry 11586, 11588* (lf.); Sierra de Yecora, Nov. 15, 1958, *Gentry & Arguelles 17666*; 6 miles east of Reparo along road from Nuri to Yecora, Dec. 11, 1959, *Felger & Stronack 3052* (lf. & cap.) "Upper edge of Oak Forest—common, leaves, green." SINALOA: Ocurahui, Sierra-Surotato, Sept. 1–10, 1941, *Gentry 6340* (fl. & lf.). Native to the rocky, calcareous, open mountain slopes through the pine-oak forests at elevations between 4,500 and 7,500 feet (fig. 38). Because of the montane elevations it occupies the most humid habitat of all the paniculate Sonoran agaves. Although I have observed the species from northern Durango and northern Sinaloa to Sierra de Yecora, Sonora, it is an uncommon plant, with relatively few individuals in small, widely scattered colonies. (Figs. 37 and 38.)

On the basis of floral morphology *A. wocomahi* belongs in the section Ditepalae, as indicated in the key to the species, page 42. It sometimes grows with *A. shrevei*, from which it is usually easily distinguished by its dark green color, larger size, or larger and more numerous distal teeth. It is more easily confused with *A. bovicornuta*, as discussed under that species (See p. 88); compare also respective ideographs in figure 4, *B*.

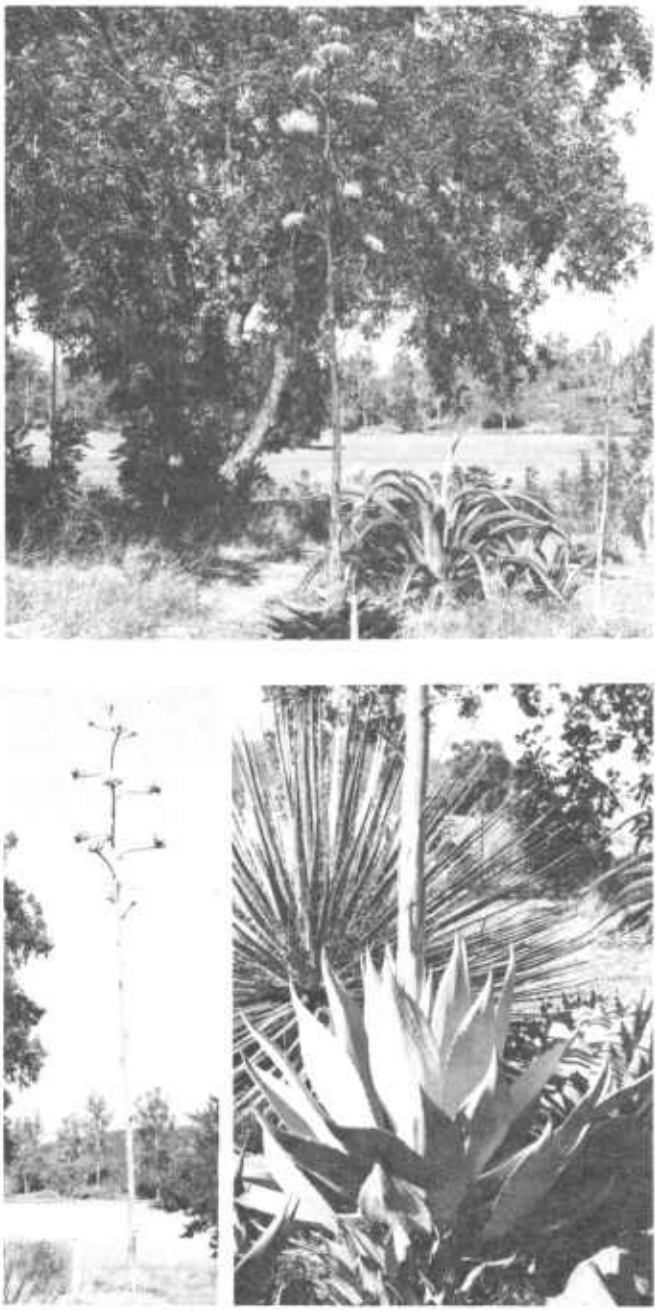
An unusual variant with very short, broad leaves is represented by *Gentry 11588*, found along the Guajaráy Scarp, a striking topographic feature described in "Rio Mayo Plants" (*13*). I have noted no intergrading of *A. wocomahi* with its neighbors.

The Warihio Indians and their Mexican neighbors called this plant "wocomahi," stating that it was sweet and suitable for eating and for making mescal. Both these peoples and the mountaineers of Sinaloa stated that the flowers were cooked and eaten like squash. The fiber of the leaves is used locally for cord, rope, and pack saddle pads. A single plant that flowered in my Murrieta garden in 1962 did not set viable seed, indicating that it requires cross-pollination. This maturation required 11 years from the small plant collected, *Gentry 10252*, in 1951. No vegetative reproduction has been observed in this species and it appears to be a confirmed seeder and outbreeder.



PN–2140, PN–2141

FIGURE 37.—*Agave wocomahi: Upper,* with budding inflorescence in garden at Murrieta, Calif.; *lower,* form with more uniform teeth among volcanic rocks on Guajaráy Scarp in southeastern Sonora.



PN-2142, PN-2143

FIGURE 38.—*Upper, Agave wocomahi* in flower at Murrieta, Calif., Gentry 10254, summer of 1962; *lower, Agave shrevei* in flower at Murrieta, summer of 1965.

For distribution of the Ditepalae group of agave, see figure 39.

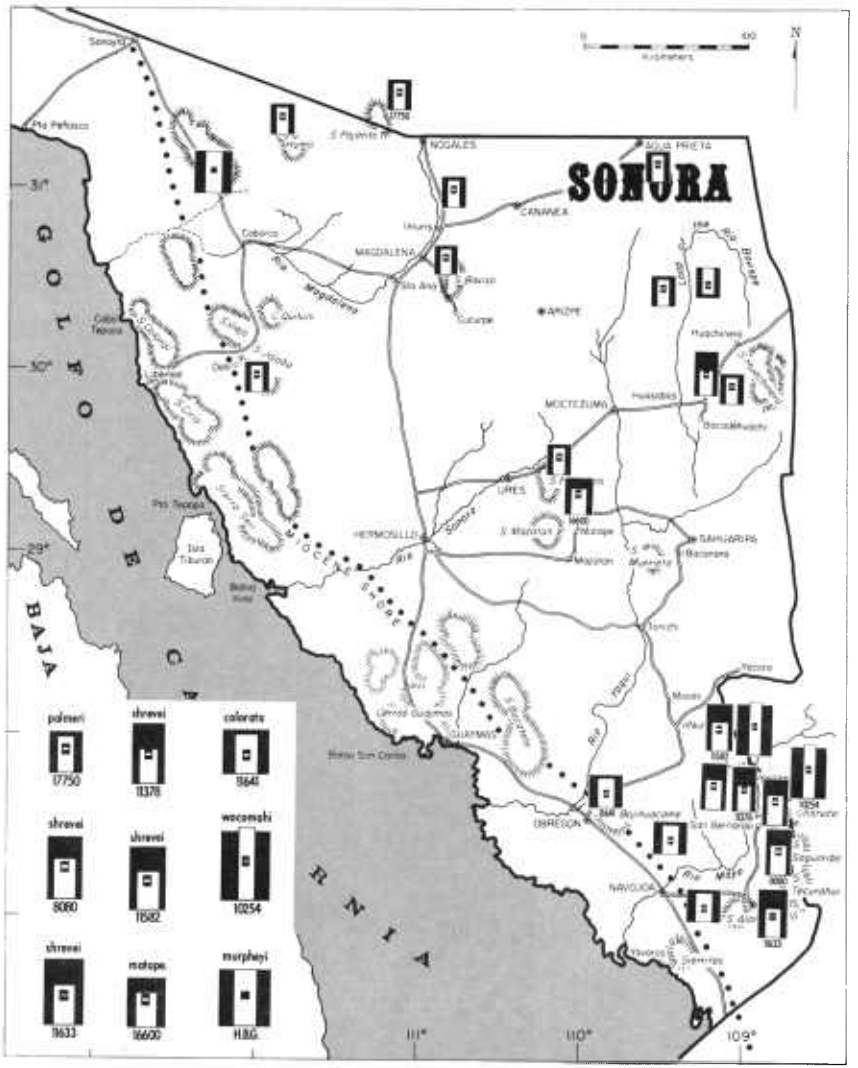


FIGURE 39.—Distribution of Ditepalae group of agave in Sonora, represented by their ideographs. Ideographs with numbers indicate flower collection at the locality occupied. (See p. 37.)

***Agave shrevei* Gentry spp. shrevei** **Figure 40**

Agave shrevei **Gentry, Carnegie Inst. Wash. Pub. 527, p. 95. 1942.**

Small to medium, light gray, glaucous rosettes, closely or widely suckering with maturity; leaves ovate, short-acuminate, 20–35

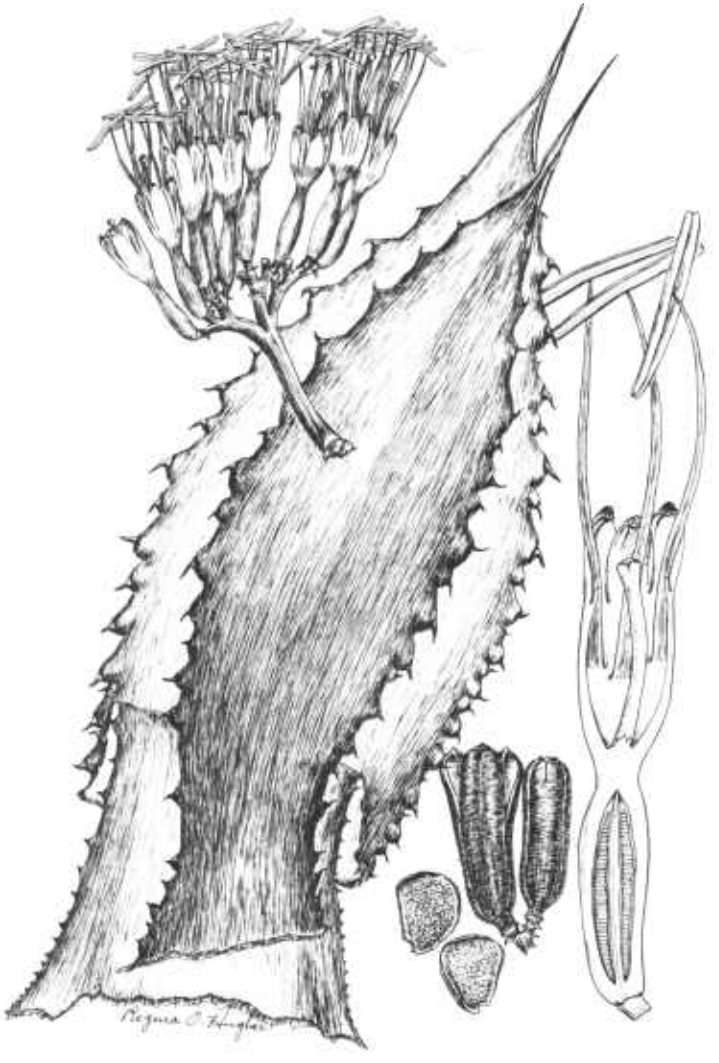


FIGURE 40.—*Agave shrevei:* Smaller leaf drawn from type, Gentry 2028; larger leaf from Gentry 11580; flower cluster × ⅛ from Gentry 19865; flower section slightly enlarged from Gentry 8080; capsules × ½ and seeds × 1¾ from Gentry 21211.

× 8–10 cm., plane to conduplicate, lanceolate, acuminate, 50–60 × 12–18 cm., generally narrowed above the base, firm, thick, straight or outcurving near the tip; teeth variable, on small to prominent teats, the larger teeth in midblade 5–10 mm. long, straight or flexed upward or downward, dark brown to gray; spine stout, mostly 25–50 mm. long, brown, acicular, with a narrow or open groove from base to above the middle; panicle 2.5–5 m. tall with 8–16 distal, ascending laterals in upper ⅓; bracts deltoid, long-acuminate, drying early; umbels small; flowers persisting erect, slender, leathery, 60–70 mm. long, light green to pale yellow, buds red-tipped; ovary 25–35 mm. long including constricted neck; tube cylindric or urceolate, 18–23 mm. deep, 10–12 mm. wide; tepals strictly erect, leathery, pea green to light yellow, unequal, the outer 10–12 mm. long with red to purplish calloused tips, plane, widely overlapping the shorter, keeled inner; filaments 40–50 mm. long, yellow or red, inserted unequally in midtube, flattened; anthers large, 22–26 mm. long, yellow; capsules oblong, 4.5–7 × 1.5–2.5 cm., short-stipitate and shortly beaked; seeds 6–7 × 4.5–5 mm., hilar notch small, the marginal wing prominent.

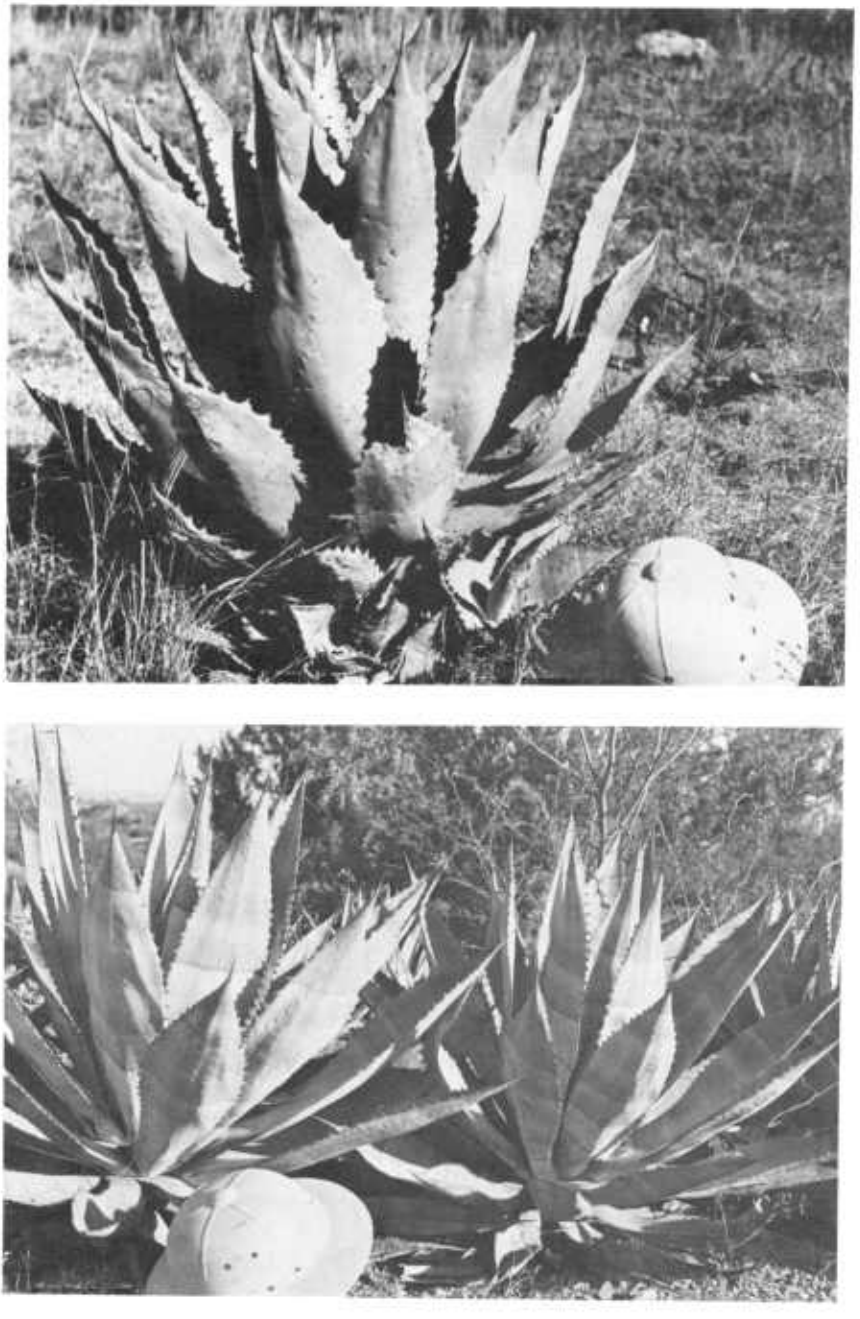
Type—*Gentry 2028,* Sierra Canelo, Chihuahua, Oct. 8, 1935 (old dried flowers) deposited in Dudley Herbarium, Stanford Univ. SONORA: Sierra Tecurahui, Nov. 1961, *Gentry, Barclay, & Arguelles s.n.* (fig. 41, *lower*); Sierra Potrero, west of Arroyo Guajaráy, *Gentry 11378* (flowered at Murrieta, Calif., August 1957); Guajaráy Scarp, north of Curopaco, *Gentry 11580* (flowered at Huntington Bot. Gard., August 1962), *11582,* Feb. 13, 1952; Rancho Santa Barbara del Agua Blanca, northwest of Curopaco, *Gentry 11598,* Feb. 14, 1952 (lf.). CHIHUAHUA: Arroyo Hondo, Sierra Charuco, April 1948, *Gentry 8080* (pl.), flowered at Murrieta, summer 1965. Common and widely scattered from middle Sonora southward on both sides of the Chihuahua-Sonora boundary, from 3,000- to 6,000-foot altitudes of the northern Sierra Madre Occidental, in open, rocky, calcareous slopes of the oak woodland and pine-oak forests. Flowers in summer. (Figs. 38, 40–42, 44.)

Known locally as "lecheguilla ceniza" or "totosali" by the Warihio Indians, who pit bake the heads for eating.

Good distinguishing features of this agave are its light glaucous gray, broad leaves with teated margins under well-developed brown teeth and its leathery perianth with deep tube, short, persistently erect tepals, much shorter than the tube. Some of the flower forms are quite striking, as the red filaments in a

PN–2144, PN–2145

FIGURE 41.—*Agave shrevei: Upper,* flowers with visiting bee; *lower,* colony of plants on Sierra Tecurahui, southeastern Sonora.



PN–2146, PN–2147

FIGURE 42.—*Agave shrevei: Upper*, large-leaved form along Guajaráy Scarp; *lower*, cultivated as food plant in Chijucu, a Mayo Indian suburb of Navojoa.

pea-green perianth. The typical or smaller leaved *A. shrevei* shows leaf resemblance to *A. flexispina* Trel., but the latter's flowers appear closer to *A. palmeri,* the tube and tepals being about equal.

The Guajaráy population with its larger leaf and variable forms shows some *A. palmeri* characters and there appears to be some introgression. The obscure relative *Gentry 11605,* cultivated in Navojoa, was reported as from Tepahue, which is adjacent to the Guajaráy country (fig. 42, *lower*). The Mayo Indian growing the plants in his garden in the "bario" known as Chijuca also stated that he grew them to eat, as the pit-baked heads were very sweet.

***Agave shrevei* subsp. *matapensis* Gentry, ssp. nov.** **Figure 43**

Small to medium, light gray glaucous, rather open rosettes, suckering late and sparsely; leaves short-lanceolate, 30–45 × 8–14 cm., mostly plane to conduplicate towards apex, the larger teeth in the midblade down-flexed, the margin nearly straight to undulate; panicles 4–5 m. tall with 8–14 laterals in upper half of shaft; flowers waxy yellow-green with tips of outer tepals reddish; filaments greenish to pink, anthers yellow; ovary 22–40 mm. long including the short unconstricted neck 2–3 mm. long; tube cylindric, 15–20 mm. long, 11–14 mm. broad; outer tepals 11–16 × 7 mm., rounded on back, thick; filaments inserted 8–10 mm. above base of tube; filaments 45–55 mm. long, slightly flattened; anthers 20–28 mm. long; capsules (*Gentry 17623*) short, 35–40 × 20 mm., short-oblong, apiculate, the valves strong and woody; seeds smokey black, mostly 5–7 mm. along straight edge, 5–6 mm. broad, rugose, scarcely winged and unfluted along margin.

Type—*Gentry 11607,* Sierra Batuc, North of Matapé, Sonora, Feb. 16, 1952, deposited in U.S. Natl. Herbarium. No. 2540344. SONORA: 2 miles east of Nacori, Feb. 16, 1952, *Gentry 11612* (lf.); between Nacori and Matapé, May 12, 1957, *Gentry 16600* (live pl., flowered at Murrieta, Calif., in 1962). Mountain pass 6–8 miles northeast of Matapé, Nov. 4, 1958, *Gentry 17622* and *17623*

Planta caule singulo vel caespitosula; foliis pallidis, glauco-viridibus, lanceolatis, 30–45 cm. longis, 8–14 cm. latis; dentibus validis, 4–14 mm, longis, subulatis, deflexis, in mammae proximis, castaneis; spine terminali 2–4 cm. longa, valida, castanea, supra canaliculata, decurrente; inflorescentia 4–5 m. alta, paniculata, cum 8–15 ramis lateralibus; floribus luteo-viridibus, ca. 50 mm. longis, gracilibus; ovario 20–40 mm. longo, apice crasso incluso; tubo 15–20 mm. longo, urceolato; segmentis inaequalibus, exterioribus 11–16 mm. longis, 7 mm. latis, apice rubro; filamentis 45–55 mm. longis, luteis, medio tubi insertis; antheris luteis, 20–28 mm. longis; capsulis oblongis 3.5–4 cm. longis, 2 cm. latis; seminibus 5–6 × 6–7 mm., nigris, enervis, apice emarginatis.

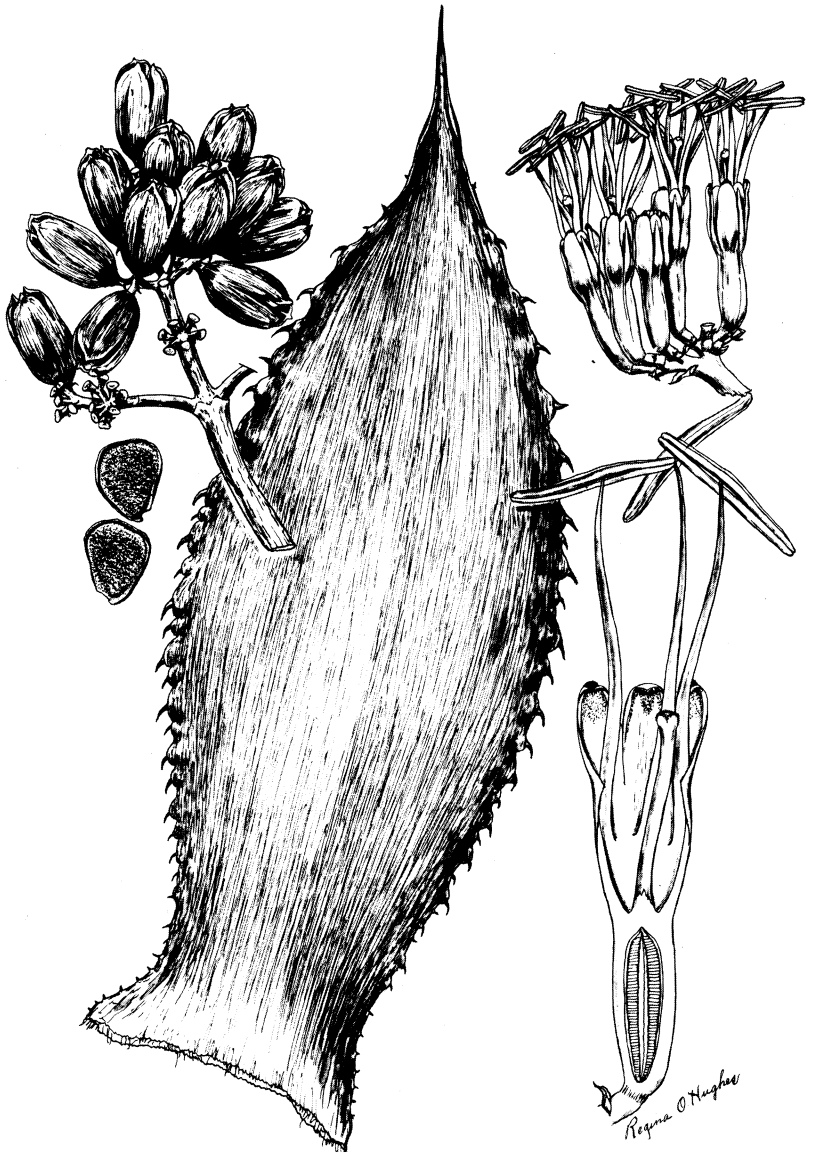


FIGURE 43.—*Agave shrevei matapensis:* Leaf drawn from Gentry 11607; flowers from Gentry 16600; cluster × ⅖, section × 1; capsules × ⅓ and seeds × 1½ from Gentry 17623.

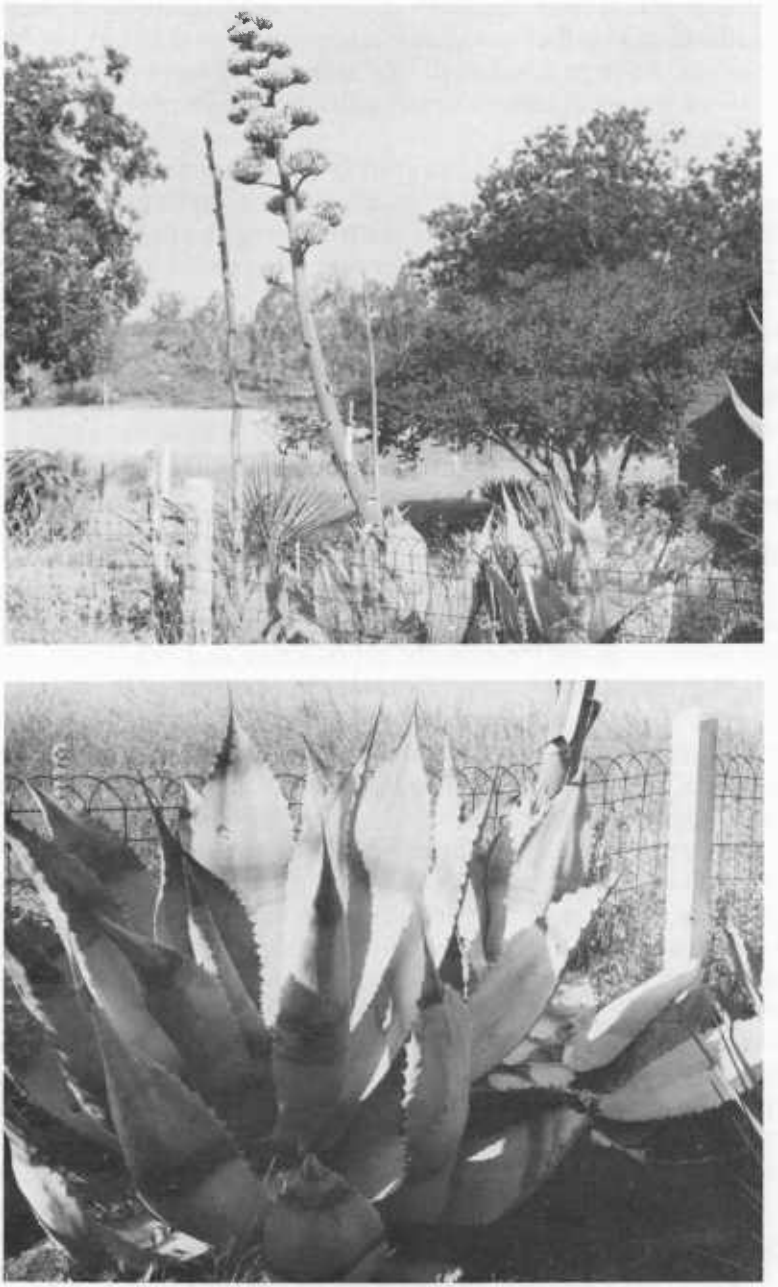
(cap. & seed). Widely scattered in sparse colonies in the savanillas of lysiloma-oak-nolina woodland on granitics and deformed limestones, alt. 2,000 to 3,000 feet. The largest colony observed was in and about the mountain pass 6–8 miles northeast of Matapé along the road to Sahuaripa.

These small to medium, light-gray glaucous rosettes resemble some forms of *A. shrevei*, from which it is distinguished by its deflexed teeth, smaller flowers with shorter ovary unconstricted in the very short neck, the broader and longer tepals in proportion to the shorter tube, and the short, broad capsules. It produces offsets late and seeds abundantly. The variability observed about Matapé indicates an outbreeding population. The flower description is drawn mainly from pickled flowers from plants that flowered in my Murrieta planting.

Agave colorata **Gentry, Carnegie Inst. Wash. Pub. 527, p. 95. 1942.**

Small to medium, light-gray, compact, few-leaved rosettes on short stems, suckering while young; leaves 25–60 × 12–18 cm., ovate, short-acuminate, thick, firm, rounded below, plane to shallowly concave above, frequently cross-zoned and red-tinted, glaucous, the margins prominently crenate, asperous; teeth mostly 4–8 mm. long, smaller below, 1–3 cm. apart, mildly flexed to straight, brown to grayish; spine subulate; straight or flexuous, 25–50 mm. long, narrowly grooved above in lower half; panicle 2–3 m. tall, narrow, with densely flowered laterals in upper ½ or ⅔ of red shaft; lower bracts leaflike, the others soon drying appressed at base, reflexed, reddish, 15–10 cm. long; flowers 50–65 mm. long; ovary including neck 24–30 mm. long, yellowish green; tube 14–16 mm. long, 14 mm. wide, yellowish; tepals 12–16 × 5 mm., coppery red to yellow, leathery, strictly erect, unequal; filaments yellow or pink, 40–50 mm. long, inserted unequally 6–9 mm. above base of tube; anthers 20–26 mm. long, eccentrally attached, yellow; fruits large, oblong, green; capsules and seeds not seen.

Type—SONORA: Peñasco Blanco, near Aquibiquichi, February 1937, *Gentry 3050* in Dudley Herbarium, Stanford Univ.; same locality, March 9, 1951, *Gentry 10270* (fl.); Rancho Bachaca, about 20 miles east of Navojoa, Dec. 19, 1951, *Gentry 11368* (live pl.); Sierra Bojihuacame, east of Ciudad, Obregon, March 1952, *Gentry & Arguelles 11641* (live pl.). SINALOA: Los Pucheros, Sierra Surotato, Mar. 17–24, 1945, open rocky slope in pine-oak forest, *Gentry 7237*. Mainly on open rocky sites in the volcanic foothills of the "tierra caliente" at elevations between 200 and 2,000 feet.



PN–2148, PN–2149

FIGURE 44.—*Upper, Agave colorata* flowering at Murrieta, Calif., in June 1965, grown from Gentry 11368. Flowering shoots of *A. shrevei* adjacent are later (see opposite page); *lower,* rosette details of *A. colorata.*

With its dimorphic tepals and large, deep tube, *A. colorata* fits nicely into the section Ditepalae. Its nearest relative, morphologically and geographically, is *A. shrevei*, from which it differs in the broader leaf with deeply crenate to undulate margins, the more densely flowered panicle with more numerous and more closely set laterals, and the shorter, wider tube and thicker ovary. *A. shrevei* grows in the higher altitudes of the Sierra Madre, while *A. colorata* in Sonora is restricted to the foothills on open rocky sites in the thorn forest.

The small live plants collected in 1951 flowered at Murrieta in June 1965, indicating a sexual generation period of about 15 years (fig. 44). The first flowers along the shaft did not set fruits, but fruits developed with ovules on the last terminal laterals. It was during the anthesis of these later flowers that a nearby specimen of *A. shrevei* came into flower. Hummingbirds visited the flowers of the two plants. From this one may infer that *A. colorata* is perhaps self-sterile and that it can be pollinated with *A. shrevei*. However, ground squirrels chewed off the capsules before seed development could be verified.

A. colorata is uncommon in nature and on my very intensive travels through its area I do not recall it from any localities except those listed above. It was reported by the natives as suitable for pit baking and was referred to as "mescal ceniza." It was perhaps formerly decimated as a sugar source by the Mayo and Yaqui Indians who surrounded its area rather densely in precolonial times. Because of its compact size and bright, glaucous leaves with pinkish cross-zones, it is an attractive ornamental, especially those plants from the type locality. It is now (1971) found in southwestern gardens (*6*).

Agave huachucensis Baker, Handb. of the Amaryllideae, p. 172. 1888.

Agave applanata var. _huachucensis_ (Baker) Mulford, Mo. Bot. Gard. Ann. Rpt. 7: 85. 1896.

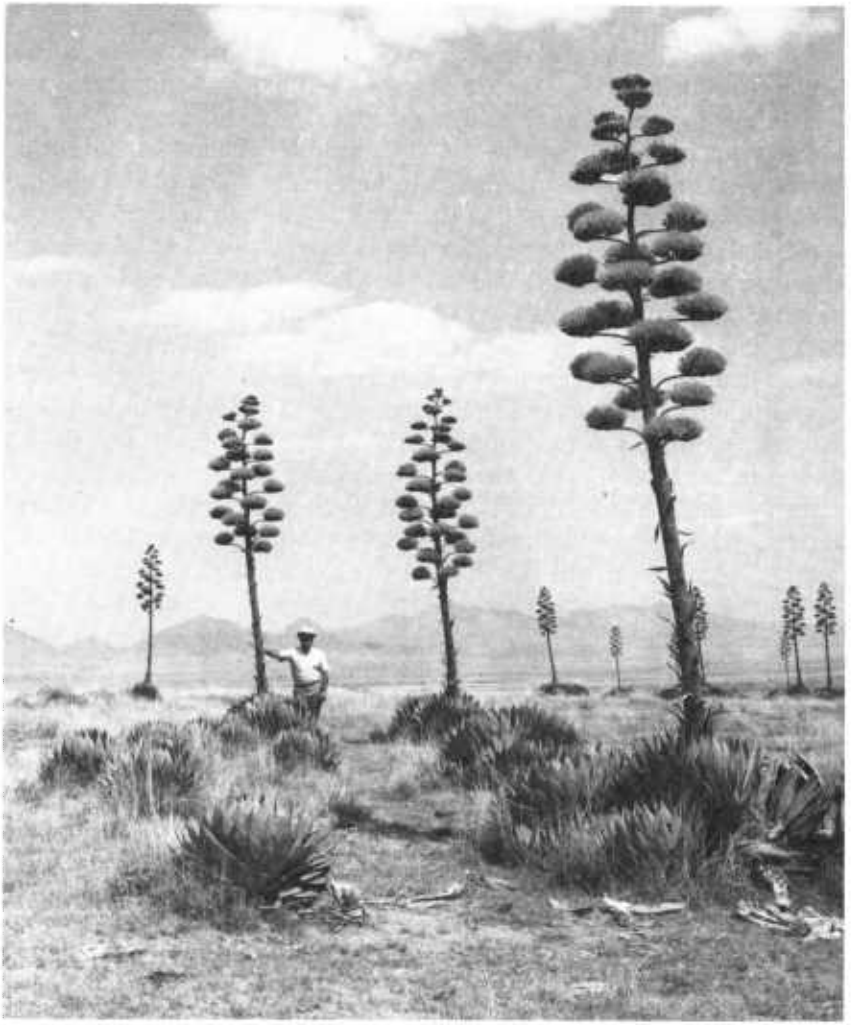
A. parryi var. _huachucensis_ (Baker) Little ex Benson, Amer. Jour. Bot. 30: 235. 1943.

Compact, light gray, multileaved, short, broad, widely suckering rosettes 5–7 dm. tall, 8–12 dm. broad; leaves 25–40 × 10–15 cm., incurving, nearly plane, ovate-lanceolate, short-acuminate, slightly narrowed below the midblade, light gray glaucous, thick, rigid; teeth small or larger, the larger along the upper part of blade 2–3 mm. long and nearly straight or 5–7 mm. long and

somewhat flexuous, the margin slightly undulate with or without a narrow corneous margin; spine 2–3.5 cm. long, brown to aging grayish, acute-triangular and flattened or hollowed above, decurrent; panicle 3.5–4.5 m. tall, deep, broad, with 24–30 horizontal laterals in upper half of shaft, peduncular bracts 10–20 cm. long, broad, drying early, recurving; flowers bright lemon yellow, 55–65 mm. long, closely clustered; ovary 30–35 mm. long, 3-angled and grooved, virtually neckless, tapering from base to tube; tube 8–10 mm. deep, 16–18 mm. wide, funnelform; tepals 19–21 mm. long, 5–6 mm. wide, lanceolate, appressed, incurving after anthesis, with open sinuses; filaments 45–65 mm. long, flattened on inner side, rounded on outer side, inserted 7–8 mm. above bottom of tube at base of tepals, with nectary rimming the tube; anthers 20 mm. long, eccentrically affixed, yellow (from *Gentry 19829*); capsules "broadly oblong, 20–25 × 55–75 mm., stipitate and beaked; seeds 6 × 8 mm." (Trel. loc. cit.).

Type—Collected by Pringle in 1884 in Huachuca Mountains, Arizona, at 5,000 to 8,000 feet elevation. SONORA: Sierra Huachinera, south of Bavispe, alt. about 7,500 feet in pine forest, May 21, 1957, *Gentry & Arguelles 16642* (photo & live pl.). Northern Sierra Madre including southeastern Arizona, where it occurs as widely scattered clones in small colonies in oak woodland and pine forests, alt. 4,500 to 7,500 feet. In Sonora it is restricted to the northeast quarter of the state. (Fig. 45.)

The Mexican populations of this taxon are not well known. Flowering specimens have not been collected from Sonora. The highlands of both Sonora and Chihuahua have scattered populations with rosette and leaf characters strongly resembling the Arizona plants around Sonoita and in the Huachuca Mountains. Some extensive stands occur west of Chihuahua city, which Trelease called *A. chihuahuana.* Without more materials for study I am reserving judgment about taxonomic changes and am reporting it under Baker's original binomial. If this group is to be considered a part of the species, *A. parryi* Engelm., then a subspecific status can be established when the morphological and geographical limits are known.



PN–2150

FIGURE 45.—*Agave huachucensis* near Sonoita in southeastern Arizona, June 1968.

Agave fortiflora **Gentry, sp. nov.** **Figure 46**

Light-gray, open rosettes up to 1 × 1.8 m., mostly single but occasionally suckering; leaves 50 × 8 to 100 × 12 cm., straightly ascending or outcurving and conduplicate, light gray glaucous, usually cross-zoned, widest in the middle, gradually narrowed above the dilated base, long-acuminate, the margin straight or small-teated under the midteeth; teeth in the midblade 5–10 mm. long, 1–3 cm. apart, generally flexed downward but also erect, smaller and variously flexed above and below the middle, with smaller interstitial teeth irregularly occurring; spine 3–5 cm. long, subulate, chestnut to light gray, rounded below, narrowly grooved above, decurrent with a narrow corneous margin to the upper teeth; surface of leaf, spine, and teeth finely tuberculate rugose; panicle 4–6 m. tall with 12–18 laterals, open and deeply ovoid in outline; bracts short, triangular, chartaceous, 5–6 cm. long at the lower laterals; pedicels 4–20 mm. long, bracteolate; flowers in dense yellow umbels, long-persisting, erect, 72–82 mm. long; ovary pale green, 45–50 mm. long, conspicuously angled below outer tepals; tube pale yellow, broadly bulging, 11–13 mm. deep, 18–20 mm. wide, the sinuses overlapping and deeply grooved below; tepals erect, yellow, 20–23 mm. long, 7–8 mm. wide, the outer rounded, linear-lanceolate, with an involute margin, obtuse, the inner with a high narrow keel and involute hyaline margins, broadly hooded at tip; filaments strong, persisting erect after anthesis, 60 mm. long, elliptic in cross section; anthers 20–22 mm. long, yellow, centrally affixed; pistil stout, triquetrously knobed at the stigma; capsules and seeds not seen.

Type—*Gentry 19808*, Huntington Botanical Garden, San Marino, Calif., July 2, 1962, deposited in U. S. Natl. Herbarium, No. 2549708 and No. 2549709 believed to have been collected

---

Planta acaulis, singularis vel surculosa, grisea, 6–10 dm. alta, 10–20 dm. lata; foliis 50–100 × 8–12 cm., lanceolatis, acuminatis, adscendentibus, planis vel conduplicatis, palidis vel glauco-viridibus, dentibus lateralis plerumque 5–10 mm. longis, 1–3 cm. separatim, plerumque retrorso-flexuosis; spina terminali recta, valida, subulata, 3–5 cm. longa, castanea vel maturitate grisea; scapo inflorescentia inclusa 4–6 m. alto, paniculato, 12–18 ramis lateralibus; bracteis 5–6 cm. longis deltoideis chartaceis; pedicellis 4–20 mm. longis, bracteolatis; floribus luteis, persistenti-rectis, congestis, 72–82 mm. longis, crassis, ovario crasso, 3-angulato, apice incluso 45–50 mm. longo, viridi; tubo 11–13 mm. longo apice 18 mm. diametro, 6-angulato, 6-furcato, infundibuliformi; segmentis rectis, 20–23 mm. longis, 7–8 mm. latis, linearilanceolatis, luteis, involutis, apice obtuso-galeatis; filamentis validus, ca. 60 mm. longis, ligulatis, base 4–5 mm. latis, 6-8 mm. supra basim tubi insertis; antheris 20–22 mm. longis, luteis; fructum et semina non vidi.

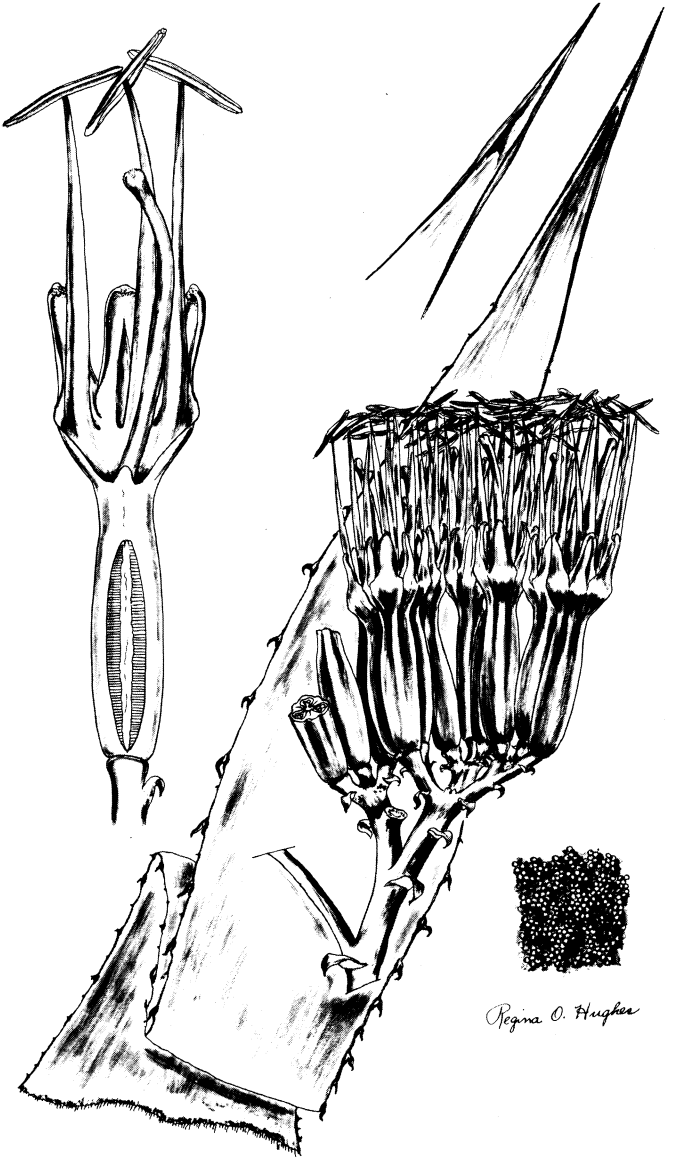


FIGURE 46.—*Agave fortiflora:* Leaf and flower cluster × ⅜; flower section slightly reduced; cuticular pattern × 18. Drawn from Gentry 19808.

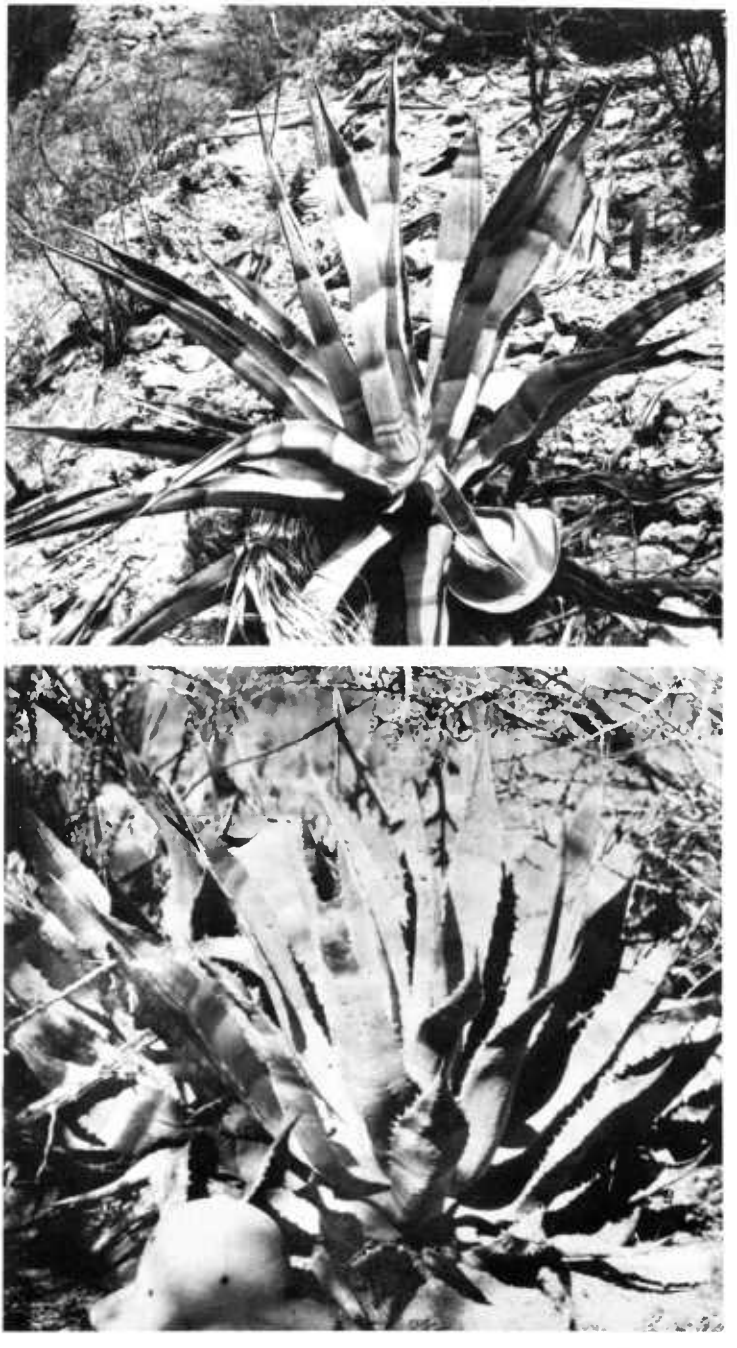
originally on Sierra Jojoba, 15 miles northeast of El Datil, Dist. Altar, Sonora, Mar. 23, 1952, *Gentry & Fox 11630* (lf. & pl.). The Huntington Botanical Garden tag was lost. Other numbers consisting of leaf specimens only, assigned here are all from SONORA: On valley plain, 3 miles northeast of Sierrita de Lopez, February 1952, *Gentry 11618;* cerro 4–5 miles north of Bahia San Carlos, Mar. 29, 1963, *Gentry and Arguelles 19881;* rocky hillslopes at north end of Ensenada Grande (=Bahia San Carlos) Nov. 13, 1964, *Felger & Russell 11455* "leaves bluish"; Cerro de la Vigia, Guaymas, south side of mountain at 1,125–feet alt., Jan. 9, 1965, *Felger & Thomas 11765,* "generally non-suckering."

Widely and sparsely scattered on the bajadas and lower slopes of the desert coastal mountains, elevations between 50 and 2,500 feet, in northwestern Sonora. It is a rare plant, the observed colonies being limited in area and members. The old Papago Indian who guided me to the clone of *Gentry 11618* stated that it was the only one he had ever seen in that valley.

There persists a nagging doubt in my mind regarding the exact origin of the type plant, which was grown from a small plant that I collected and sent to the Huntington Botanical Garden. The identifying tag was lost during the decade of its culture, but the late Joseph Schneider, a head gardner, believed I had collected it in Baja California. However, I remember no such plant in Baja California and it matches none of my collections from the peninsula. The leaves are closely matched, however, by my 1952 Sonoran number *11630.* Unfortunately, despite our recent efforts, neither Felger nor I have been able to find flowering plants in Sonora.

This light-gray, glaucous xerophyte is distinct in floral morphology; the large flowers are strong (whence the name, *fortiflora*) and long lasting, persisting erect in close-set umbels long after anthesis. The ovary is thick, roundly 3–angulate, with the grooves from the tepal sinuses furrowing the thick neck. The tube is broad and bulging at the attachment of the filaments and 3–angulate, with the rounded corners descending from the outer tepal bulges. These characters aline it with Trelease's section Umbelliflorae of Baja California. Its relatives are *A. shawii* Engelm. and *A. goldmaniana* Trel., from which *A. fortiflora* is easily distinguished by its simple habit (i.e., not branching from the leaf axils), its light-gray color, its less open tube, and its erect rather than spreading tepals. The flattening of the filaments is extreme in *A. fortiflora,* making them almost strap shaped and quite the broadest observed in the genus.

The coastal population of *A. fortiflora* in the mountains north of San Carlos Bay consists of a long-leaved, boldly crossed-zone



PN-2151, PN-2152

FIGURE 47.—*Agave fortiflora: Upper,* long-leaved form in the mountains north of Bahia San Carlos; *lower,* source of Gentry 11618 in valley near Sierrita de Lopez, western Sonora.

form, withered and collapsing with protracted drought when observed in the spring of 1963 (fig. 47, *upper*). The leaf margins are unbordered and generally straight to undulate, but the isolated clone or colony found on the plain near Sierrita de Lopez has small, sharply rising teats under the midteeth (fig. 47, *lower*).

The flowering season appears to be in summer, since the Huntington Botanical Garden specimen flowered during June and July. The rosettes observed produced offsets sparingly and old or extensive clonal colonies are rare. The widely scattered members indicate a freely seeding sexual species. The single plant that Johnston found at San Pedro Bay (*29*, p. *1,004*) may have belonged to this species. Locally, the plant is called "lechuguilla" and the Papago Indian guide said it was good for pit baking.

***Agave zebra* Gentry, sp. nov.** **Figure 48**

Rosettes mostly single, medium-size, low spreading, rather open, light gray, xerophytic, strongly armed, 4–6 × 10–16 dm. leaves generally 50–80 × 12–17 cm. lanceolate, broadest near the middle, narrowed above the base, deeply guttered, arcuate, thick, rigid, light gray glaucous, scabrous, conspicuously cross-zoned, with strongly undulate margins; spine 3.5–7.5 cm. long, acicular, mostly very narrowly grooved above, scabrously decurrent for 5–10 cm. to upper teeth, yellowish brown to light gray; teeth large, 25–40 on a side, on prominent teats, those on the midblade mostly 10–20 mm. long, with broad, low, scabrous bases, 1–3 cm. apart, flattened, variously curved and flexed, gray with castaneous tips; panicles to 6–8 m. tall, narrow, with large bracts towards the shaft base and 7–14 small laterals in upper ¼ to ⅕ of shaft; flowers small, yellow, 40–55 mm. long; ovary 25–32 mm. long, slender, cylindro-angulate, straight from angled very short pedicels, neck slightly constricted and 6-sulcate; tube funnelform, 6–7 mm. deep, bulging, deeply sulcate; tepals about equal, 12–15 mm. long, 5–6

Planta plerumque caule singulo vel caespitosula, 40–60 cm. alta, 100–160 cm. lata; foliis paucis, 30–40, lanceolatis, 50–80 cm. longis, 12–17 cm. latis, glauco-zonatis, pallidi-viridibus, conduplicatis, reflexis, valde scabrosis; margine valde crenata, dentibus supra mammas plerumque 10–20 mm. longis, reflexis, pallido-brunneis vel albis; spina terminali robusta, 3.5–7.5 cm. longa, leviter flexuosa, albocastanea, supra anguste canaliculata; inflorescentia paniculata, scapo incluso 6–8 m. alta 7–14 ramis remotis; bracteis ad basim grandis, siccis, triangulis; floribus luteis, ca. 50 mm. longis; ovario cylindrico-angulato apice incluso ca. 30 mm. longo; tubo infundibuliformi, 6–7 mm. longo; segmentis ca. 12–15 mm. longis, aequalibus; filamentis medio tubi insertis; capsulis parvis, ovatis vel oblongis, 4–5 cm. longis, 1.2–1.5 cm. latis, stipitatis, brevi-apiculatis; semenibus 4.5–5 × 4–4.5 mm., ovatis, rugosis.

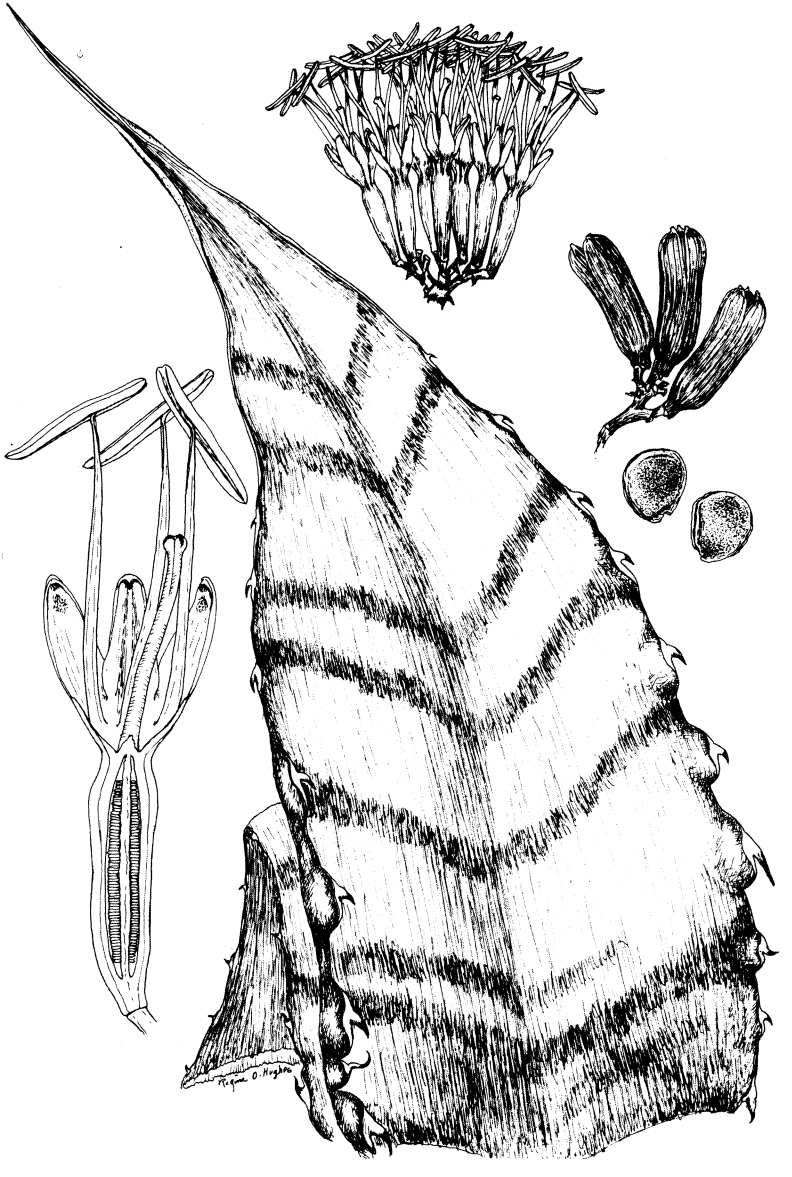


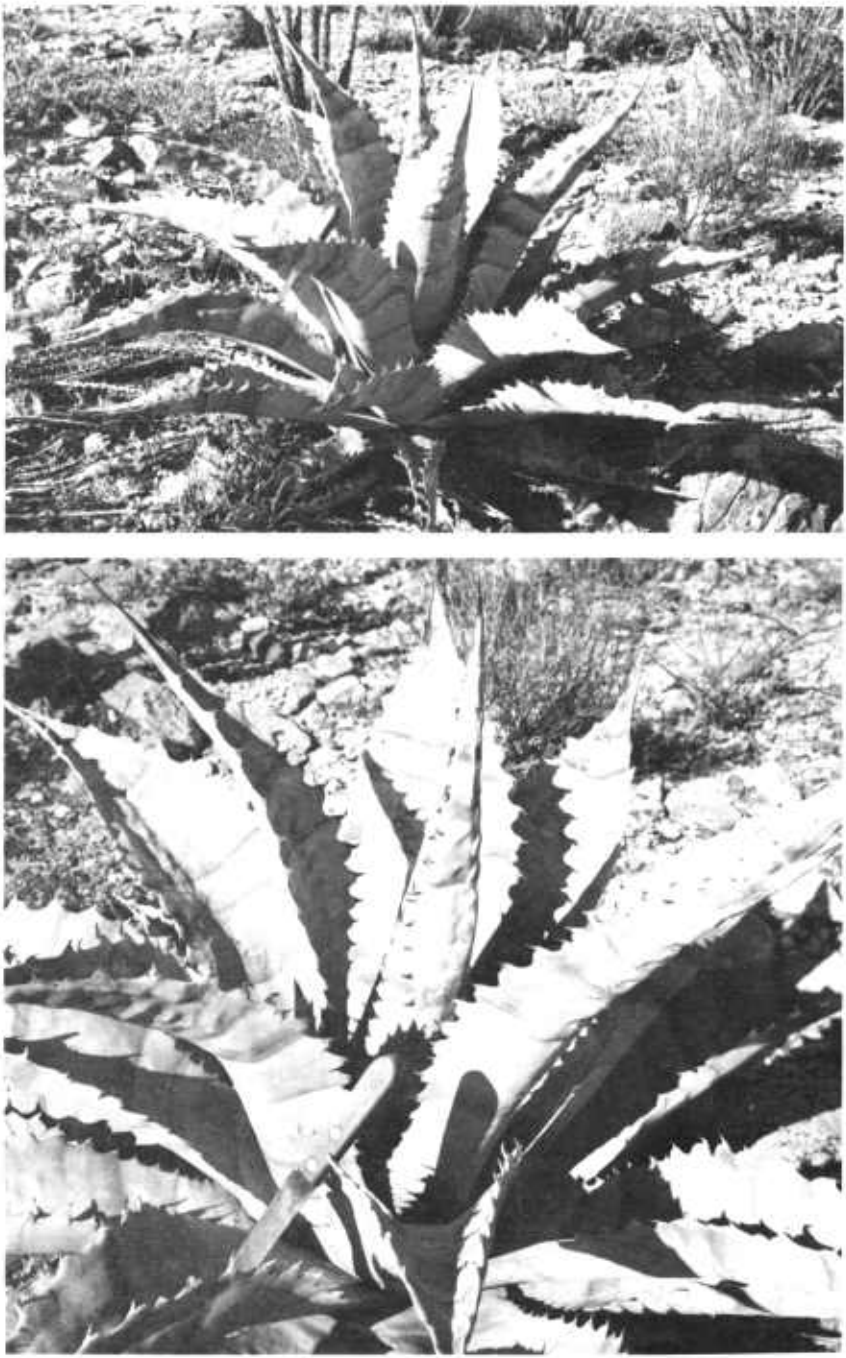
FIGURE 48.—*Agave zebra:* Flower cluster × ⅓; flower section slightly enlarged; capsules × ½ ; seeds × 2. Drawn from Gentry 21984.

mm. wide, erect to ascending, lanceolate, revolute, cucullate, the inner prominently keeled; filaments broad, inserted in midtube, 35–40 mm. long; anthers small, 15–18 mm. long; capsules small, mostly 4–5 × 1.2–1.5 cm., oblong to obovate, the walls strong and conspicuously lined, stipitate, apex round, apiculate; seeds 4.5–5 × 4–4.5 mm. obliquely rounded, concave on one or both faces, the marginal wing very low, hilar notch shallow.

Type—*Gentry 21984,* Puerto Blanco, Sierra del Viejo, about 30 miles south of Caborca, Sonora, July 24, 1966, open rocky slopes of limestone mountain, alt. 2,000 to 2,500 feet, deposited in U.S. Natl. Herbarium No. 2549706 and No. 2549707. Also from the same mountain on the northern end, alt. 2,500 to 4,000 feet, Feb. 25, 1951, *Gentry 10205* and Apr. 5, 1963, *Gentry & Arguelles 19897* (lf. & live pl.); Puerto Blanco, alt. 1,500 feet, September 6, 1965, *Gentry & Arguelles 21207* (fruiting). SONORA: Cerro Quituni, about 26 miles south of Caborca, Apr. 7, 1963, *Gentry & Arguelles 19899* (lf.). (Figs. 49 and 50.)

A. zebra is certainly known from only the two above-named limestone mountains with a desert climate. Sierra del Viejo, a north-south trending range about 20 miles long, has a large population of this *Agave.* Many young flowering shoots were observed in April 1963, but were still without buds; July appears to be the principal flowering month. On Feb. 11, 1894, Mearns collected *Mearns 305* in the Tule Mountains along the Sonora-Arizona boundary. The specimen in the U.S. Natl. Herbarium consists of two leaves; one is *A. deserti,* the other suggests *A. zebra,* having large, down-flexed teeth on prominent teats. Both leaves were cut above the base.

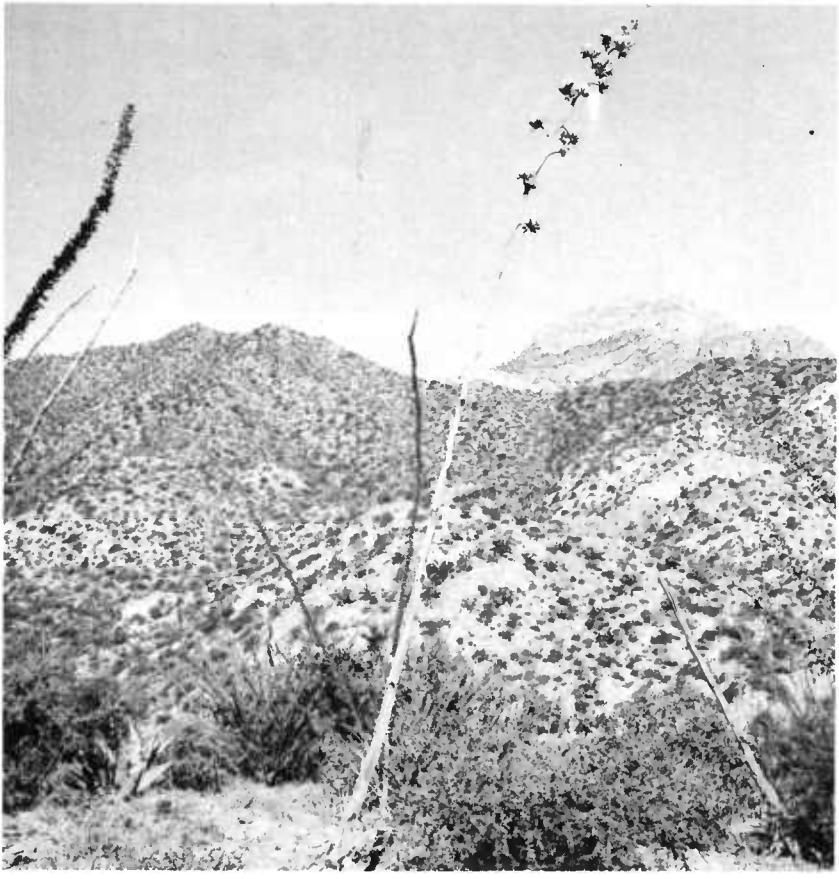
The aspects of the leaves (fig. 49) are like those of *A. marmorata* Roezl of Puebla and Oaxaca, and the lax narrow panicle is like *A. deserti.* The flowers collected from four plants of *A. zebra* show considerable variation, mainly in size, the proportions of the main organs being relatively about the same, an exception being the neck. All the ovaries show a moderate neck constriction, but when sectioned longitudinally, the carpel cells may reach the tube bottom level as they taper into the base of the style, as in the flower drawn by Regina Hughes (fig. 48). In other flowers, the carpel cells terminate 3–4 mm. below the tube bottom level. The flower structure shows relationship to those of *A. fortiflora,* but are much smaller, are without the long neck, and lack the latter's long-lasting qualities. The leaves are quite different from those of *A. fortiflora.*



PN–2153, PN–2154

FIGURE 49.—*Agave zebra* on limestone rubble on Sierra del Viejo, Sonora.

A. zebra was used for a short while for making mescal, but no such activity has been observed since 1950. The leaves have a rather weird aspect; marbled crossbanding on deeply guttered, outcurving leaves, flagrantly armed with prominent teeth. For desert gardens it could play the beast to accompany the beauty, *A. pelona,* already naturally sympatric but not crossing at all.



PN–2155

FIGURE 50.—*Agave zebra* inflorescence with capsules on Sierra del Viejo, in September.

Agave subsimplex **Trel., Mo. Bot. Gard. Ann. Rpt. 22: 60. 1911.**
Figure 51

Small, single or cespitese, glaucous, colorful, low-spreading rosettes, 20–35 cm. tall, 50–70 cm. broad; leaves variable, 12–35 × 3–5 cm., lanceolate to ovate, long-acuminate to short-acuminate, but little narrowed towards the base, thick, rigid, rounded on

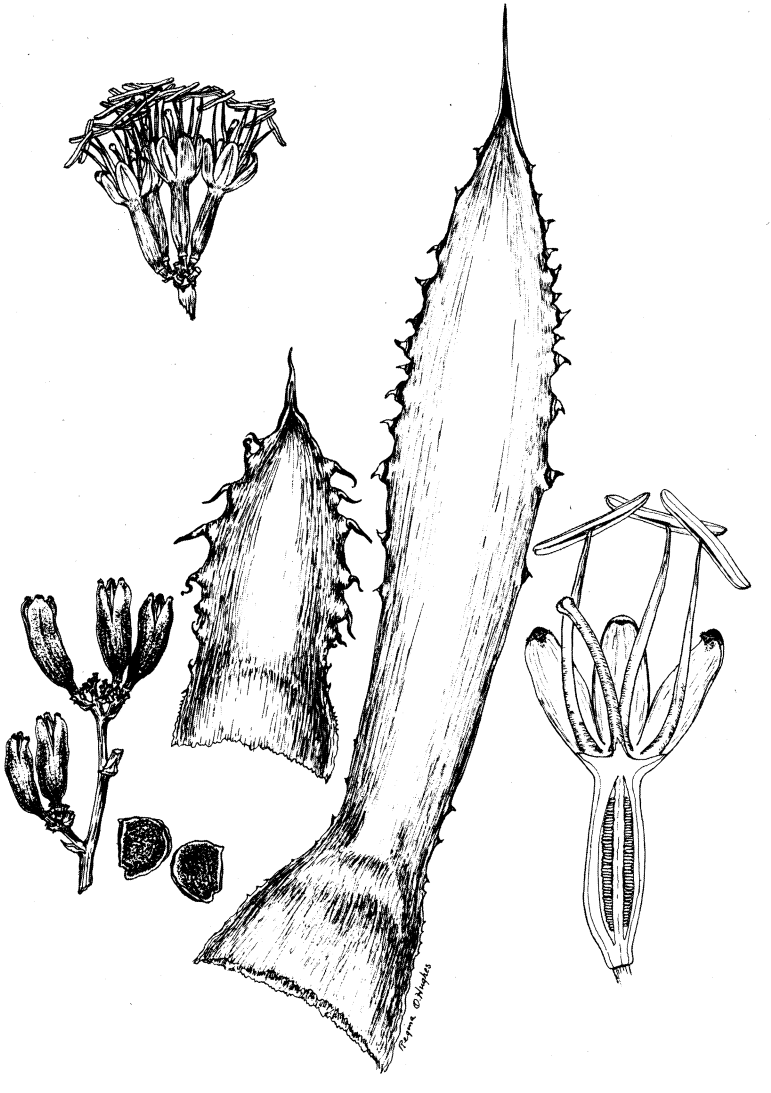
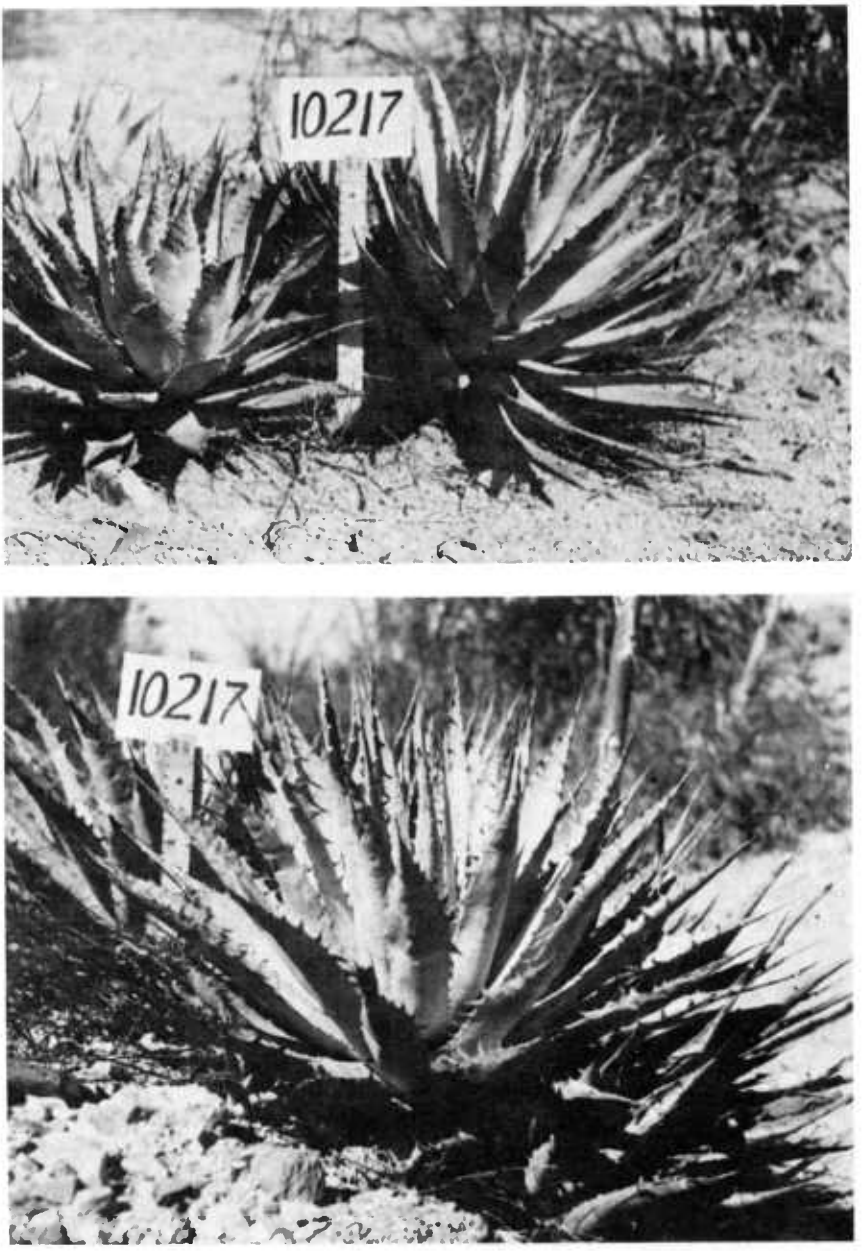


FIGURE 51.—*Agave subsimplex:* Larger leaf drawn from Gentry 10217; smaller leaf, capsules × ⅓, and seeds × 1¾ from Gentry 10221; flowers from Felger & Bezy 14171, section × 1, cluster × ⅖.

back, hollowed in inner face, gray glaucous or light yellow green, or sometimes purple-tinged, the margin nearly straight or strongly teated; teeth variable, friable, the larger 3–15 mm. long, straight or variously flexed, rarely bicuspid, brown or more often yellowish gray; spine subulate, 2–4 cm. long, not or but little decurrent, frequently sinuous, shallowly grooved above, glaucous gray; panicle slender, narrow, 2–3.5 m. tall, with 5–8 short laterals; flowers in small umbels, yellow to pink, 40–45 mm. long; ovary about 25 mm. long with a unconstricted long (5 mm.) neck; tube shallow, spreading, 3–4 mm. deep, 10 mm. wide; tepals 12–15 × 6–7 mm., equal, ascending, elliptic, plane, widest at the middle, apiculate and scarcely hooded; filaments 25–28 mm. long, round in cross section, inserted below base of tepals 3 mm. above bottom of tube; anthers 13–15 mm. long, centrically attached; capsules 40 × 15 mm. to 35 × 10 mm., variable, oblong, sometimes narrowly so, light glaucous (*Gentry 10221*), bluntly apiculate, narrowly or broadly stipitate, the valves thick and striate-nerved; seeds (*10221*) mostly 4.5 × 3 mm., sooty black, roughly lunate, hylum notch narrow and the opposite corner frequently apiculate, edges rimmed with a sharp, winglike flange.

Type—SONORA: Seal Island, just off Tiburon Island, Apr. 13, 1911, *Rose 16811;* Puerto Libertad, May 22, 1939, *Gentry 4486* (flg.); north end of Sierra Coloral, Feb. 28, 1951, *Gentry 10217* (lf., cap., & pl.); Cerro Punta Tepopa, Mar. 1, 1939, *Gentry 10221, 10222, 10223* (lf., cap., & pl.); Kino Point, Nov. 17, 1923, *MacDougal & Shreve s.n.*; Punto Cirio, about 7 miles south of Puerto Libertad, Jan. 3, 1963, *Hastings, McClanahan, & Turner 63–8* (lf. & cap.)–small leaf with big teats; Tiburon Island, vicinity of Tecomate, June 14–22, 1951, *Whiting 9047* (lf.) "Abundant on rocky mountain slopes on west side of island. This one from NW corner"; foothills at north side of Cerro Tepopa, 4 miles by road west of 9 miles by road south of Desemboque, May 15, 1966, *Felger & Bezy 14171* (fl.); 6.3 miles south of Desemboque San Ignacio, middle bajada with sandy soil, May 14, 1966, *Felger & Bezy 14182* (fl.) "Few scattered colonies, lvs. faintly cross-handed, tepals white to pinkish." Isla Cholludo (Roco Fuca, Seal Island), Oct. 30, 1958, *Felger 2721* (lf. & fl.), "common & widespread, suckering, leaves bluish. Inflo. branched, only one plant in fl.; anthers yellow, filaments & tepals dustry rose-colored; base of tube pinkish white." Known only from coastal Sonora, where it it thinly scattered in small colonies on the outwash slopes of the granitic and volcanic mountains and the adjacent islands. (Figs. 52 and 55.)



PN–2156, PN–2157

FIGURE 52.—*Agave subsimplex* along arid Sonoran coast. Scattered clones show individual variation.

This small, xerophytic, dusky agave is closely related to *A. deserti* and *A. cerulata* Trel., as expressed by their common characters of small variable leaves, the nearly tubeless flowers, and the narrow small panicles, which characterize the section Deserticolae. I think the characters outlined in the key to species (p. 45) should be sufficient to distinguish *A. subsimplex* from *A. deserti,* although depauperate plants of the latter in the Lechuguilla Desert of Arizona resemble *A. subsimplex.* The two species are not known to cohabit, but it is possible they may be found together on some unexplored mountains in northwestern Sonora, such as the coastal Sierra del Alamo. *A. subsimplex* may be more closely related to the polymorphic *A. cerulata* of Baja California, as indicated by the small, variable leaves and the narrow, oblong, waxy capsules. However, the Sonoran plants have more spreading rosettes, gray not yellow, with thicker, wider, less acuminate leaves, and the filaments are inserted below the base of the tepals. In *A. subsimplex* the nectarious interliner of the tube, from the rim of which the filaments ascend, does not completely fill the tube, as it does in *A. cerulata.* The flowers of *A. subsimplex* are smaller than those of *A. cerulata,* 40–45 mm. vs. 45–60 mm. The whole section Deserticolae around the Gulf of California needs intensive field study.

The Seri Indians, a maritime hunting and gathering people of the Sonoran coast, called this agave "ahmmo," as nearly as I could render the sound, and stated that it was gathered for cooking and eating. Whiting noted the Seri name as "den;kl." Small amounts of sapogenin (0.07–0.14 percent) were found in the leaves. Offsets that were collected for the Huntington Botanical Garden and my own live collection did not survive.

***Agave deserti* Engelm., Acad. Sci. St. Louis Trans. 3: 310, 370. 1875.**

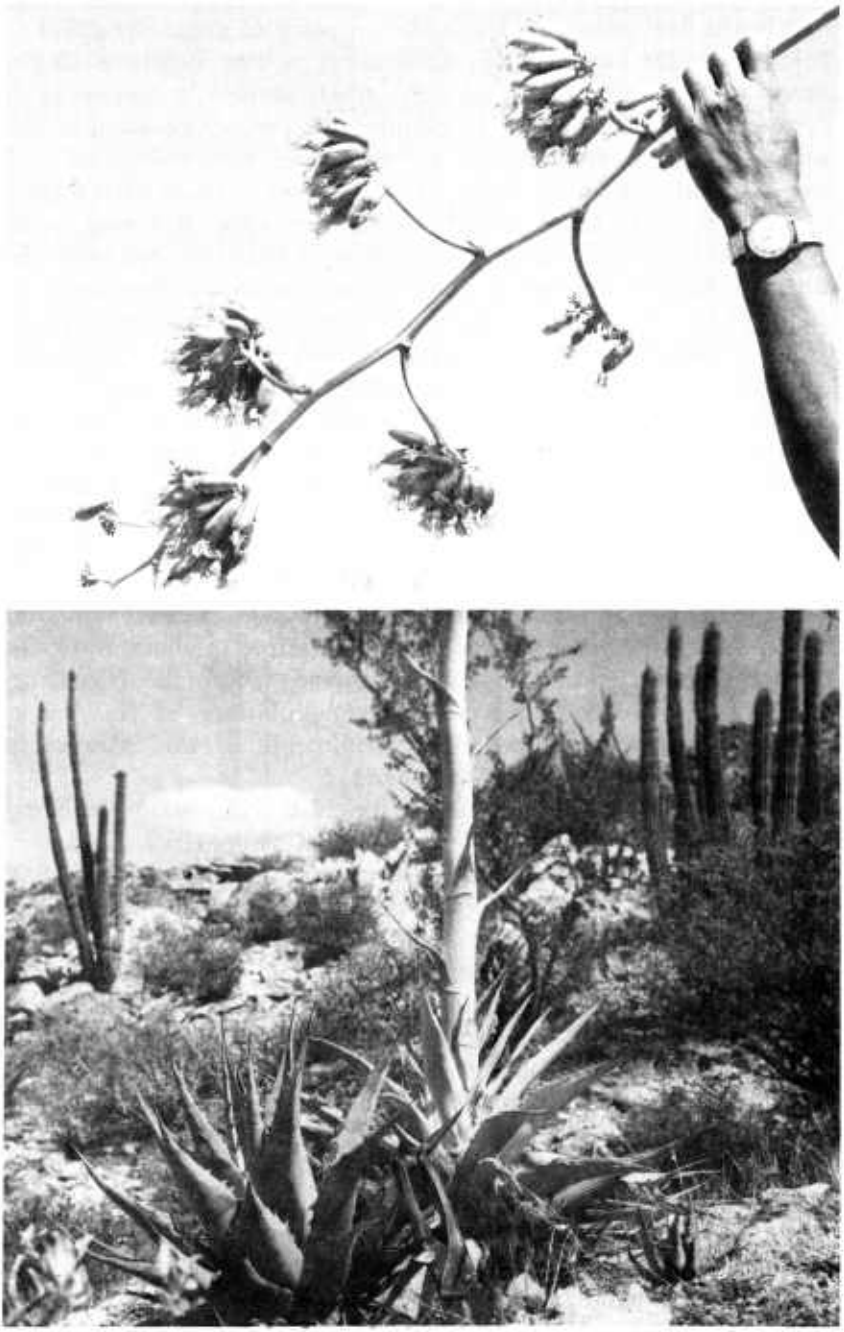
***Agave consociata* Trel., Mo. Bot. Gard. Ann. Rpt. 22: 53. 1911.**

Medium-size, light-gray, freely suckering rosettes mostly 30–40 cm. tall, 40–50 cm. in diam; leaves variable, mostly 25–40 × 6–8 cm., lanceolate to linear-lanceolate, scarcely narrowed above the broad clasping base, acuminate, gray glaucous to bluish glaucous, often cross-zoned, thick, rigid, concave above, convex below, usually regularly armed with slender-cusped teeth, from small, the larger 2–3 mm. long, to large, the larger 6–8 mm. long, gray, loosely attached, mostly 15–30 mm. apart; spine strong, generally 2–4 cm. long, light brown to grayish, openly grooved above, decur-

rent to the first or second tooth above; panicles generally 2.5–4 m. tall, on slender shafts with scarious triangular bracts 8–15 cm. long and 6–12 short laterals with small umbels in upper ¼ to ⅕ of shaft; flowers yellow, 40–53 mm. long; ovary 22–35 mm. long with a slightly narrowed neck 4–6 mm. long, greenish; tube shallow, spreading, 4–5 mm. deep, 12–15 mm. wide, lined with a thick nectiferous disk; tepals equal, 14–19 mm. long, 6–8 mm. wide, light yellow, broadly linear, spreading at anthesis, rounded and abruptly hooked inward at apex; filaments 25–35 mm. long, inserted at base of tepals; anthers 13–18 mm. long, yellow; capsules ovoid to oblong or obovoid, mostly 3.5–5 cm. long, 1.5–1.8 cm. wide, thick-walled, short-stipitate; seeds black, 4 × 5 mm.

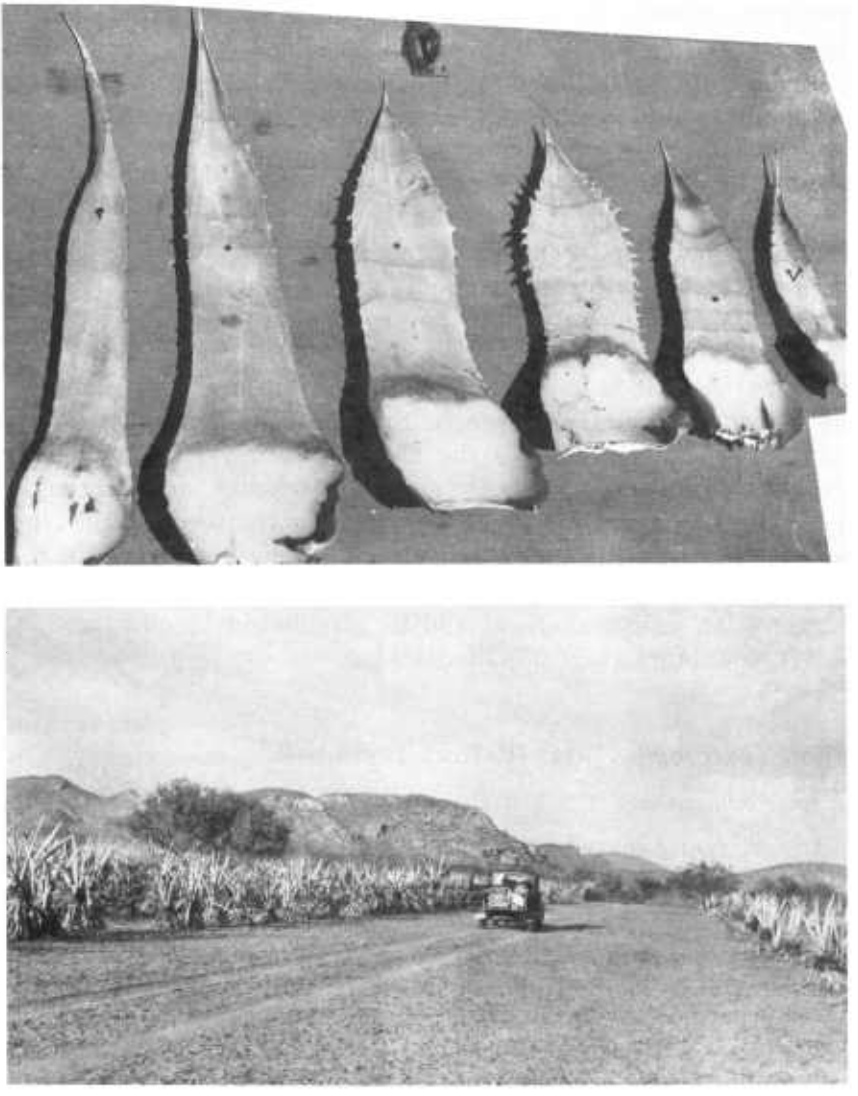
Type—Based on *Emory in 1846* and *Hitchcock & Palmer in 1875* collected on Rancho San Felipe, San Diego County, California. SONORA: At km. 2,509 in mountain pass southeast of Quitovac, alt. 1,800 to 2,000 feet, on granitic slope, Sept. 4, 1965, *Gentry & Arguelles 21203* (fruiting) (fig. 53). This is the only Sonoran collection observed. It has been collected in Arizona near the Sonoran border; Cabeza Prieta Mountains, *Gentry 20590,* and in the Tule Mountains, *Mearns 305.* The latter is about 100 miles from the collection southeast of Quitovac, where the plants are sparsely but widely scattered. Other populations of the species are to be expected on the rocky pediments of the intervening mountains in Sonora. (Fig. 54, *upper.*)

The Lechuguilla Desert, one of the most arid regions in North America, takes its name from the small pauperized *A. deserti* found thinly scattered over the rocky mountain slopes of this part of southwestern Arizona. The leaves commonly are only 20–25 cm. long. Other than the small size, the characters of the plants are quite like those of the species; rather broad, gray, crossbanded, thick, rigid leaves and slender, small panicles. As with other Arizona populations, the rosettes sucker more sparingly than the rosettes of California colonies, and the large cespitose Californian clones are absent. Although the extensive population of *A. deserti* at the type locality along the arroyo San Felipe is morphologically homogeneous, there are other localities showing wide variability in leaf forms. One of these localities is Piñon Flats by the northwestern slopes of Santa Rosa Mountain along route 74 in southern California, and another, described by Ivan Johnson (*29*) is on Angel de la Guarda Island. Some of the leaf variants to be found at Piñon Flats are shown in figure 54, *upper.* The sources of such genetic turbulence may be due to hybridization, but if so, the parents involved have not been detected. *A consociata* Trel. is only



PN–2158, PN–2159

FIGURE 53.—*Agave deserti* in granitic hills southeast of Quitovac, Sonora. Organ pipe cactus and acacia tree in background.



PN–2160, PN–2161

FIGURE 54.—*Upper, Agave deserti* leaves from population around Pinon Flats, Southern California. Not an unusual range of variability for an *Agave* species; *lower, Agave fourcroydes* in Obregon plantation southeast of Ciudad Obregon, Sonora.

one of the variant forms and has no value as a specific name. Cave reports (Madroño 17: 166. 1964) a collection from Baja California, *Hutchinson 710,* with chromosomes n=59, indicating polyploidy in this species. As far as chromosomes have been reported for the genus, 30 is the basic number, typified by a karyotype of 5 long and 25 short chromosomes.

A. deserti is known to have been eaten by the Arizona Indians, e.g., the Yumans and Papagos (*8,* p. *49*). It may still be eaten by the Papagos in northwestern Sonora. San Francisquito is an important Papago village within the probable range of the species. The plant contains little or no sapogenins and I find no report of medicinal uses. It is important to wildlife; birds visit the flowering stalks for nectar and insects. Small rodents live around the plants and are protected by the armed rosettes. The pack rats, *Neotoma,* make nests among the clumps of rosettes, gnaw through the leaves, and eat the flowers and perhaps the seeds. Wild bighorn sheep, like cattle, eat the flowering shoots. As a wildlife resource growing in our most arid of deserts, *A. deserti* deserves conservation and perhaps should be established by planting on desert mountains where it is now lacking.

***Agave fourcroydes* Lem., Ill. Hort. 11: 65.1864.**

***Agave sullivani* Trel., U.S. Natl. Herbarium Contrib. 23: 119. 1920.**

Large, sword-leaved rosettes developing a thick stem 1–1.7 m. tall; leaves straight, rigid, 1–1.8 m. long, 8–12 cm. wide, linear, thickly rounded at base, guttered, acuminate, the margins straight with regularly spaced, slender, dark brown teeth 3–6 mm. long; spine stout, conical, mostly 2–3 cm. long, dark brown, openly short-grooved above at the base; influorescence an open panicle 5–6 m. tall with 10–18 laterals in upper half; flowers greenish yellow, 60–70 mm. long; ovary 35 mm. long; tube 15–16 mm. deep, 15 mm. wide; segments subequal, 17–16 × 3 mm., wilting and twisting before or at anthesis, sharply reflexed when dry; filaments 55–60 mm. long, inserted 8 mm. above bottom of tube; an-

thers 20 mm. long. (Measurements from dried flowers of *Berger 6–VIII–09,* U.S. Natl. Herbarium.)

The typical plantation form of this fiber resource, "henequen," is still (1971) represented in Sonora by the Obregon plantation 12 miles southeast of Cuidad Obregon, *Gentry 11361.* The planting stock was reported to have been obtained from the Pericos plantation, Sinaloa, which in turn was reported by the owner-manager of the Pericos plantation to have been brought from Yucatan in 1890. In 1951, the Obregon planting was reported to be about 25 years old and occupied several hundred acres (figure 54, *lower*). However, it had never been harvested except in a desultory hand-labor way by one or two resident families. The 15–18 inches of annual rainfall was apparently not sufficient to produce a large enough leaf for first-quality fiber.

On several occasions I have searched the panicles for capsules with seeds but without success. One would expect that the related *A. pacifica* Trel., which is in the same section of the genus and which occurs in the surrounding coastal thorn forest, would cross-pollinate occasionally, but no instance was found. The Obregon and similar plantings probably represent a sterile clone, perhaps of hybrid origin, which has been transported for fiber planting around the world.

Propagation is made by transplanting the rhizomatous offsets produced during the early years of growth. They are preferred over the bulbils of the inflorescence because they grow more vigorously and require fewer years to reach the commercial production stage. Fiber as a cottage industry from the Obregon plantation goes into local trade.

The leaves contain less than 1 percent sapogenins, which as a side product from the bagasse of fiber operations in eastern Mexico and elsewhere has been utilized for synthesizing cortisone and some of the sex hormones. The plant occurs widely as a backyard cultivate or fence plant. It was found at El Triumfo, Cape District, Baja California, *Gentry 11268,* and I find it unseparable from *A. sullivani* Trel. described from La Paz in the same area.

For distribution of the Deserticolae and the Ensiformae sections of agave, see figure 55.

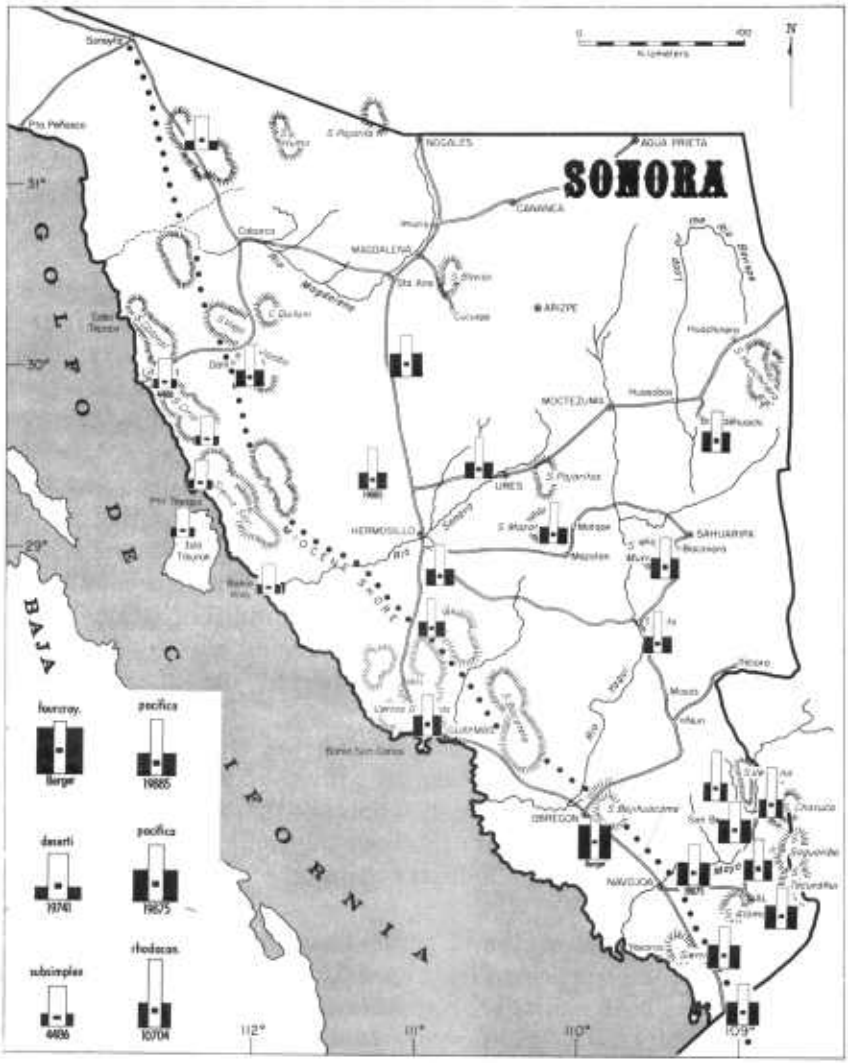


FIGURE 55.—Distribution of *Agave* in Sonora, sections Deserticolae and Ensiformae, represented by their ideographs. Ideographs with numbers indicate flower collection at the locality occupied. (See p. 37.)

Agave rhodacantha **Trel., U.S. Natl. Herbarium Contrib. 23: 117. 1920. Figure 56**

Large, single or cespitose, multileaved, radial rosettes 2–3 m. tall, 3–5 m. in diameter, truncate, 5–9 dm., or acaulescent; leaves

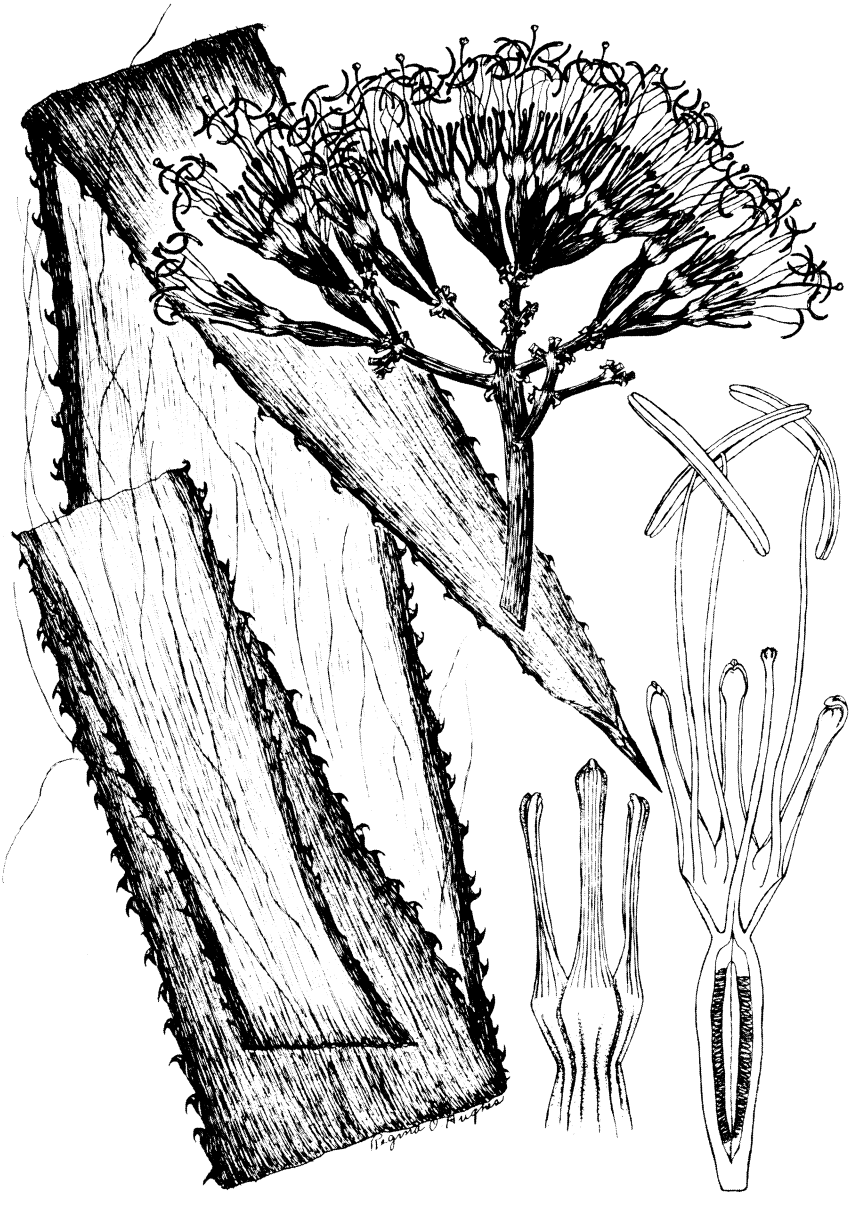


FIGURE 56.—*Agave rhodacantha:* Leaf and flower umbel × ¼; flower sections slightly enlarged. Drawn from Gentry and Gilly 10704.

1.4–2.5 m. × 8–15 cm. linear, hard-fibrous, rigid, straight, much thickened and scarcely narrowed at base, green to faintly glaucous green, smooth, the margin straight to undulate; teeth regular, mostly 4–8 mm. long, firm, slender, very sharp, flexed upwards, dark brown, mostly 1–3 cm. apart; spine 1–2.5 cm. long, conical but frequently with a subulate tip, dark brown, and with a short open groove above; panicle 7–9 m. tall, deep, broad, with 30–45 large remote laterals; flowers green with tepals yellowing at anthesis, 55–65 mm. long (dried & relaxed); ovary 25–35 mm. long, including short neck, fusiform; tube urceolate, 8–10 mm. long, 9–10 mm. wide; tepals subequal, 16–23 mm. long, 4 mm. wide, linear, strongly involute, rounded and strongly hooded at apex, wilting at anthesis and soon reflexing; filaments 40–45 mm. long, inserted 5–7 mm. above bottom of tube; anthers 14–28 mm. long; capsules 7–8 cm. long, 2.5–3 cm. wide, oblong, shortly beaked long-stipitate, the stipe 10–15 mm. long; seeds large, oblique, 8 × 10 mm., the curved margin not winglike, the hylum notch shallow.

Type—*Lundstrom in 1909*, Mocorito, Sinaloa, in Mo. Bot. Gard. Herbarium, St. Louis (reported as lost). SONORA: 5 miles northwest of Conejos, along Arroyo Guajaráy north of San Bernardo, Dec. 22–25, 1951, *Gentry 11376*. Cultivated in Tupeyeca, Rio Mayo, originally from Sierra Charuco, *Gentry, Barclay & Arguelles 20479*.

Trelease's description is very brief. The above description is based primarily upon 3 flowering specimens collected in Nayarit: 1–2 miles southwest of Jalisco, on lower slopes of Cerro San Juan, July 9, 1951, *Gentry & Gilly 10806;* 1 mile east of Mazatan along road to Compostela, July 6, 1951, *Gentry & Gilly 10786;* 7–8 miles west of Compostela, along road to Mazatan, June 27, 1951, *Gentry & Gilly 10704* (fig. 56). Widely scattered along the more moist mountain slopes at elevations from 2,000 to 3,500 feet from southern Sonora at least to about Bahia Banderas, Nayarit. It is rare in Sonora.

The very long, rigid leaves and large inflorescences with large, long-stipitate capsules distinguish this agave from its near relative, *A. pacifica*. However, leaf size and armature of *A. rhodacantha* can become quite variable and some of the forms with small distal teeth are inseparable in themselves from *A. pacifica*, like *Gentry & Gilly 10756*, 1 mile east of Mazatan along road to Compostela, Nayarit, but this collection has the long-stipitate capsules of *A. rhodacantha*. It is not known if the two species hybridize, but some of the variants suggest they do. Some young

plants received from the Tres Marias Islands, *Gentry 11565, 11567*, appeared to represent *A. rhodacantha* and are to be identified with the "giant Agave" referred to by Nelson (North Amer. Fauna 14: 7–13. 1899); Maria Madre Island, May 3–25, 1897, *Nelson 4264* (cap. & lf.). During the 1940's and 1950's it was being exploited on Maria Madre Island for its long fibers with labor of the convicts incarcerated there.

This western long-leaved population of the section Ensiformae eventually may be found cospecific with eastern Mexican taxa, including *A. gutierreziana* described by Trelease from Oaxaca, a name of the same date as *A. rhodacantha*. Other long-leaved taxa, *A. elongata* Jacobi, *A. candalabrum* Tod., and *A. spectabilis* Tod. appear closely related, but they are light glaucous and appear to belong with *A. angustifolia* Haw., an older name.

I once made a search for *A. rhodacantha* at Mocorito, the type locality, but found nothing. Lundstrum quite possibly brought the plant in from a nearby mountain or perhaps the planting, if such existed, has been destroyed.

***Agave pacifica* Trel., U.S. Natl. Herbarium Contrib. 23: 118. 1920.**
Figure 57

***Agave yaquiana* Trel., op. cit.: 120.**
***A. owenii* I.M. Jtn., Calif. Acad. Sci. Proc., ser. 4, 12: 999. 1924.**

Short-stemmed, multileaved, freely suckering, sword-leaved, radial rosettes, 1–1.5 m. tall, 1.5–2 m. diameter; leaves mostly 50–120 × 4–8 cm., linear to linear-lanceolate, rigid, straight to falcate, ascending, guttered, green or glaucous green to yellowing green, margins nearly straight; teeth regular, mostly 3–6 mm. high, 15–30 mm. apart, dark brownish to black, the cusps flexed upward; spines 15–20 mm. long, dark brown, flattened above at the base, otherwise conical, the tip short or subulate; panicle 3–6 m. tall with 6–20 horizontal to ascending, short, trifurcate laterals in upper ⅓ to ¼ of shaft; bracts triangular, 5–12 cm. long, appressed, scarious; flowers greenish yellow, glaucous lavender to brownish red or pale green in the bud, 45–65 mm. long, the tepals wilting before or at anthesis, reflexing; ovary 20–30 mm. long including the short neck, fusiform, 6-grooved at apex, pale green; tube 6–12 mm. deep, 10–13 mm. in diameter, 6-grooved from the tepal sinuses, pale green; tepals subequal, 15–24 mm. long, 4–5 mm. wide, appearing narrower with involution, linear, withered and sharply reflexed in post-anthesis; filaments 35–45 mm. long, inserted in midtube; anthers 18–30 mm. long, eccentrically affixed; capsules 35–50 × 20–26 mm., ovoid to oblong, short-stipitate,

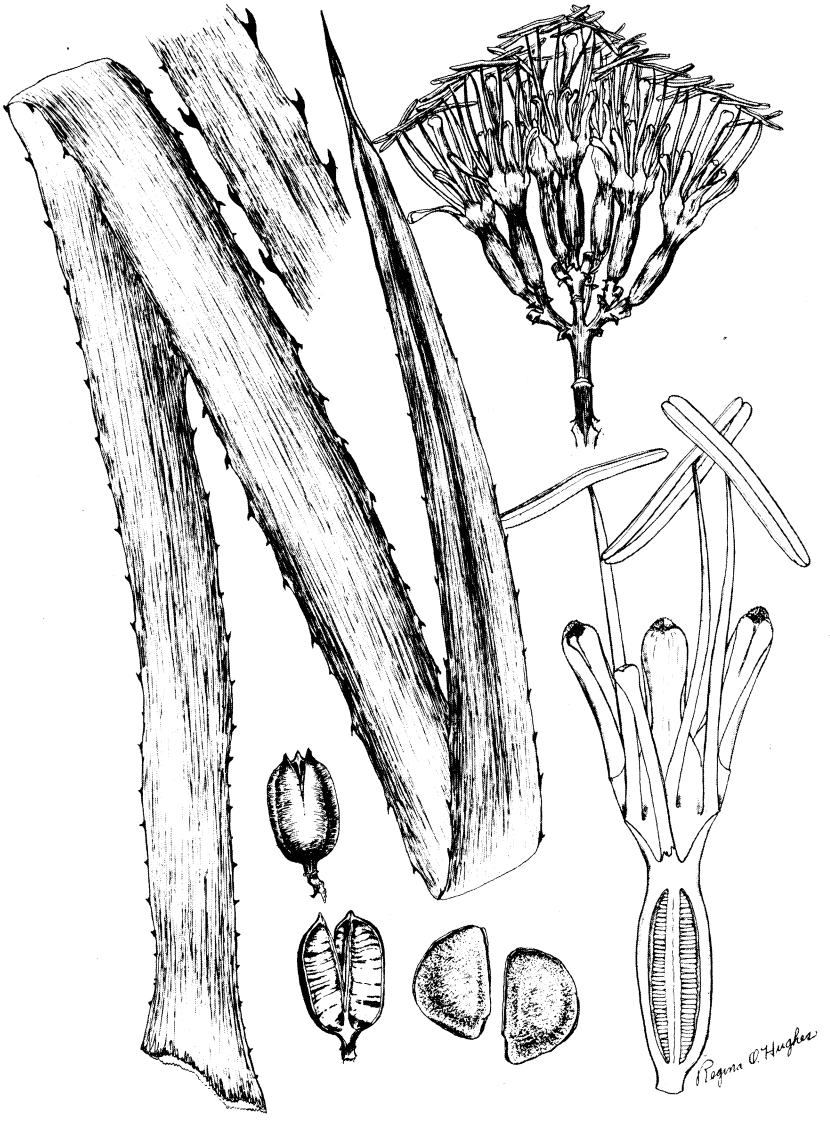
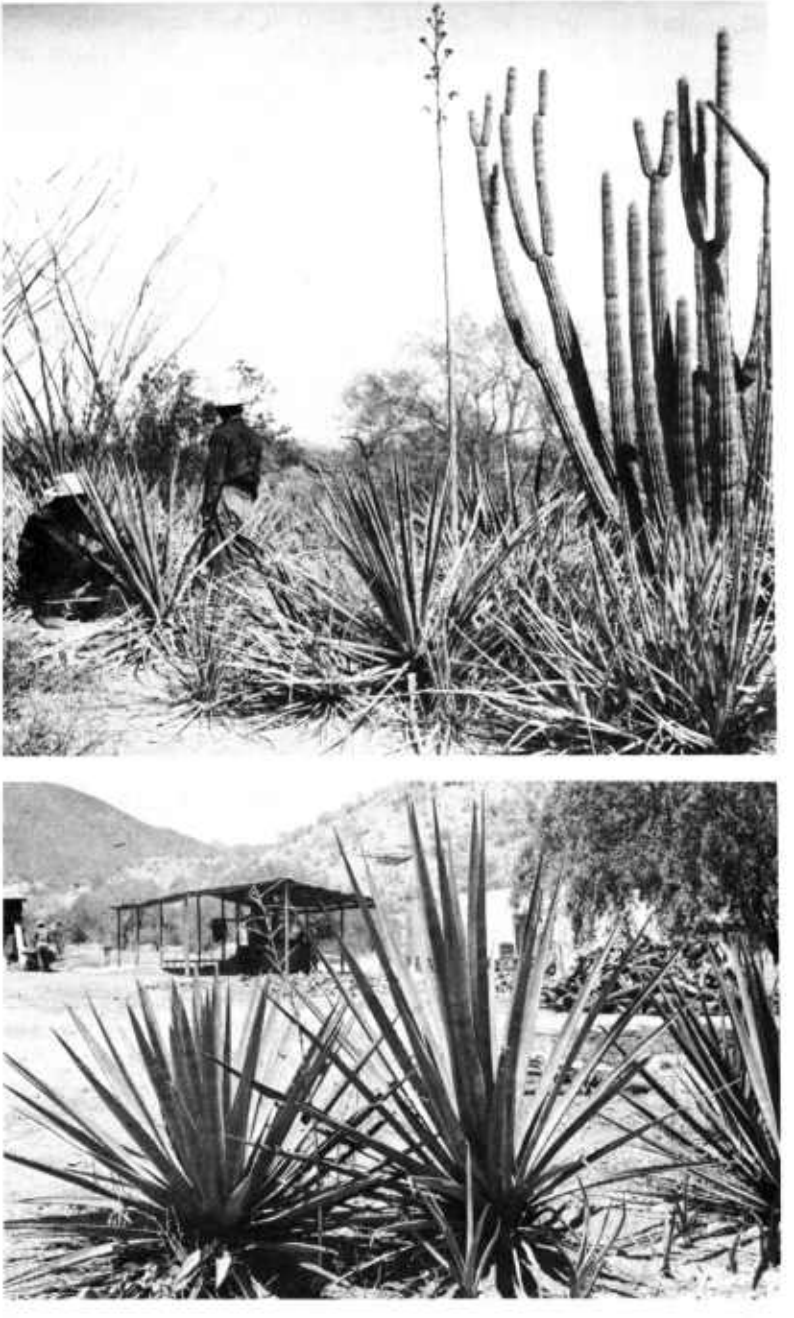


FIGURE 57.—*Agave pacifica:* Leaf drawn from Gentry 19875; leaf section from Gentry 10280; flowers from Gentry 19875, cluster × ⅓, section × 1; capsules × ⅓ and seeds × 2 from Gentry 10278.

short-beaked at apex; seeds large, 8–10 × 5–8 mm., shiny black, oblique, with a broad outcurving wing or margin, hylum notch very shallow or lacking.

Type—Trelease in 1904, from Creston Island, Mazatlan, Sinaloa, Mexico, in Mo. Bot. Gard. Herbarium, St. Louis. SONORA: Between "Ures & Hermosillo, 8/18/00," *Trelease 391* (type of *A. yaquiana*); islet in Guaymas Harbor, Apr. 14, 1921, *Johnston 3085* (type of *A. owenii*); *Gentry 11346;* 4 miles north of Rancho Tinaja, Alter District, Feb. 27, 1951, *Gentry 10212* (in bud); 8 miles east of Ures, Mar. 11, 1951, *Gentry 10280;* 6–8 miles northwest of Bacadéhuachi, May 21, 1957, *Gentry 16644;* near Navojoa, Mar. 28, 1963, *Gentry & Arguelles 19875* (fl.); San Bernardo, Rio Mayo, *Gentry & Arguelles 10258;* Sierra Tecurahui, District de Alamos, Oct. 26–28, *Gentry, Barclay, & Arguelles 19359* (fl.); Sonora-Sinaloa border along highway, *Gentry, Barclay, & Arguelles 19656, 19657* (fl. only); near Alamos, March 1910, *Rose, Standley, & Russel 12847, 12954;* vicinity of Empalme, *Rose, Standley, & Russel 12260* (lf. & cap.); 7 miles north of La Colorado Mina San Fernando Road, May 5, 1948, *Wiggins 11640* (lf. & fl.); Peon, between Rio Yaqui and Empalme, *Wiggins 6463;* vicinity of Hermosillo, *Rose, Standley, & Russel 12430;* Camoa, Rio Mayo, Jan. 25, 1899, *Goldman 302* (lf. & fl.); Tonichi, hills above Rio Yaqui, Sept. 8, 1941, *Spicer s.n.*; between Nacori Grande and Reveico, 10 miles from Nacori Grande, District Sahuaripa, alt. about 2,350 feet, Nov. 14, 1953, *Felger, Soto & Lenks 229* (lf. & fl.); 40 miles south of Navojoa and 15 miles north of Sinaloa borders, coastal plain, Mar. 9, 1960, *Felger & Stronck 3139* (lf. & fl. Tepals are unusually long, 28 mm., tube 12 mm., dried fl.) "Perianth chartruse, stamens yellow-green; inflo. 10–12 feet tall"; near Sabino, 10 miles southeast of Alamos, short-tree forest, Jan. 22, 1961, *Felger 5050* (lf., fl., & cap.) "Inflo. ca. 15 feet high; fls. greenish, lvs. bluish green"; 9 miles south of Torres, Oct. 22, 1965, alt. 825 feet, *Hasting & Turner 65–184* (lf.). SINALOA: Capadero, Sierra Tacuichamona, alt. 3,000 feet, rocky, sunny hill slope in oak woodland, Feb. 13, 1940, *Gentry 5630.*

This agave is characteristic of the coastal thorn forest of Sinaloa and southern Sonora and is also widely scattered in the short-tree forest of the Sierra Madrean foothills below the oak forests; see distribution map, figure 55. It is thinly scattered in the arborescent desert of northwestern Sonora. It occupies the sandy, gravelly, and rocky soils of plains and mountains from sea level to 3,500 feet. It is the most common agave of both Sonora and Sinaloa (fig. 58). The only agave in this region likely to be con-



PN–2162, PN–2163

FIGURE 58.—*Agave pacifica: Upper,* at its northern limits near Rancho Datil; *lower,* at Bacanora still, wild plants transplanted show variability of seeding population.

fused with *A. pacifica* is *A. aktites* a smaller, bluish-leaved, big-headed, member of the section Ensiformae (Rigidae of Berger), growing on the maritime sands of Isla Lechuguilla, Sinaloa, and the adjacent mainland. *A. pacifica* is related to the *A. angustifolia* complex of eastern Mexico and Central America. *A. pacifica, A. collina* Greenm., *A. elongata* Jacobi, *A. kirchneriana* Berger, *A. bergeri* Trel., and others too numerous to mention here, form a most difficult area of agave taxonomy yet to be systematically resolved.

There is a rather even spread of variability through the extensive populations of *A. pacifica*. The coastal population have shorter leaves with a wide midspread, while the more interior populations have longer, narrower leaves and may become more lax in forest shade, with a concomitant lengthening of stem. The northern Sonora form is more xerophytic with narrow, stiff, heavily armed leaves *(A. yaquiana)* but the dark-brown, upward-flexed, slender-cusped teeth, although variable, are characteristic throughout. *A. owenii* is a local form with low, broad, blackish distal teeth and a short, conic spine. The teeth on Johnston's type are at most 5–6 mm. long, not "20–35 mm." as was printed (loc. cit.). The flower varies in size and ratio of tube to tepals, but there is no correlation of floral variability with leaf difference. Flower color varies during development and between individual plants.

Large, black, viable-looking seed is regularly produced, bulbils are not uncommon, and rhizomatous suckers are widely deployed around the older rosettes. Individual sexual variability, therefore, occurs between the widely scattered thickets, which are composed genetically of identical individuals. The flowering season starts in November, especially in the south, and continues until March. The inflorescences in the north are frequently delayed by the lower winter temperatures. The nectariferous flowers attract many insects during the spring dry season, and judging by the many birds observed, the high inflorescence is also an attractive, sustaining perch. The firm, sharp teeth and spines are woundingly repellent to man and other large mammals, but protective to rodents and rabbits. Altogether, the plant is a wildlife asset.

The leaves have a thick, strong fiber, comparable in tensile strength to henequen, and are used locally for cordage. The famous "mescal bacanora" is made from the population growing wild about the settlement, Bacanora, near Sahuaripa in eastern Sonora (fig. 58). This mescal has a distinctive flavor not matched by any others even when it is made from other populations of the same species farther south. Whether this flavor is due to inherent genetic constitution, to local soil or other ecologic factors, or to

the kind of bacteria or method used in the primitive still has not been determined. Mescal bacanora continues to be an epicurean product among the northwestern mescal drinkers. Were it properly aged before being sold, it should find a distinctive place among the fine tequilas of Mexico.

Analyses of several samples showed the leaves to contain little or no sapogenins, the highest found having 0.2 percent of tecogenin, hecogenin, and chlorogenin; *Gentry 11337* from Cieneguita, 40 miles north of Guaymas, Sonora. The heads have been pit baked and eaten but are inferior to lechuguilla ceniza and jaiboli, according to local informants. Following are some notes concerning this agave, taken during a journey up the Arroyo Guajaray in December 1951.

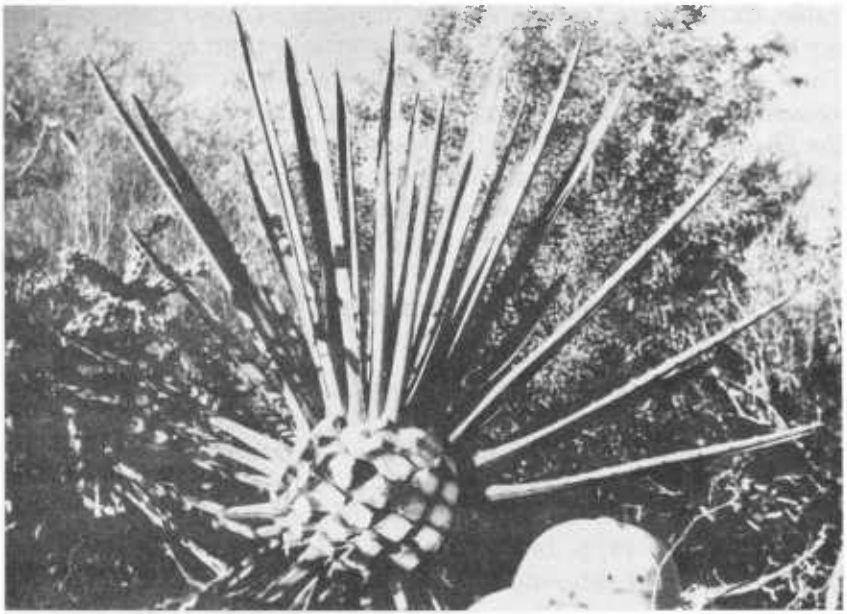
A. pacifica was observed frequently all along the trail from Chorijoa to Conejos in the short-tree forest; commonly as scattered individuals or in groups of 2 to 4 or 5, rarely crowded clumps of a dozen. Inflorescences in the bud were common and a few flowers were opening beyond Conejos on the higher slopes; flower buds brownish red to dull green. Flowers are greenish yellow at anthesis. In this area with elevations from 2,000 to 3,500 feet the species is abundant. Common names are magüe and mescal.

***Agave aktites* Gentry, sp. nov.** **Figure 59**

Small, glaucous, surculose rosettes with broadly globose stems, 4–7 × 6–11 dm.; leaves 40–60 × 2–3 cm., linear, straight, patulous, unequal, nearly flat above, concave below, broadly clasping at the base, bluish glaucous gray, sometimes cross-zoned, smooth or asperous; spine short, 12–20 mm. long, broad and flattened above at the base, abruptly subulate, dark brown to grayish; teeth 3–5 mm. long, mostly 3–5 cm. apart, dark brown, generally upcurved with subulate flexuous tips; panicle 3–4 m. tall, narrow, with 10–14 short laterals in upper third of shaft. Flowers and capsules unknown.

Type—*Gentry 11470,* Isla Lechuguilla, north of Topolobampo, Sinaloa, México, Jan. 7, 1952, on sand dunes with coastal thorn forest, deposited in U.S. Natl. Herbarium No. 2539974. Also from Sinaloa: 8 miles southeast of Los Mochis in coastal thorn forest

Planta caulis globosis surculosa, 4–7 dm. alta, 6–11 dm. lata, species foliorum anguste glaucedine insignis; foliis 40–60 × 2–3 cm. minerais patulis inaequalibus, plerumque trans-zonatis; dentibus lateralibus 3–5 mm. longis antrorso-flexuosis 3–5 cm. separatim, badius; spina terminali valida supra ad basim plana ad apicem subulata, 12–20 mm. longa; scapo inflorescentia inclusa 3–4 m. alta, paniculata, 10–14 ramis lateralibus; flori et fructum non vidi.



PN–2164

FIGURE 59.—*Agave aktites* on sandy island of Lechuguilla. Leaves of this plant were cut for analysis sample and for herbarium specimens, exposing the broad globose heads, or "cabeza."

near sea level, Jan. 4, 1952, *Gentry 11423*. SONORA: Near el faro in Yavaros, on coastal sand dunes with *Jatropha, Croton, Opuntia*, Oct. 19, 1966, *Gentry & Arguelles 22015* (lf., photo.).

Although the fruit and flower of this plant are unknown, it appears to belong in the section Ensiformae. It is distinguished from the more common *A. pacifica* by its smaller size; broad, short globose stem; light-bluish, glaucous, narrow leaves; broad, flat spine; and narrow panicle. Its small size, remote teeth, and geographic position suggest affinity with *A. datylio* across the Gulf of California in the Cape District. Its taxonomic position will become clearer when flowers and fruits can be obtained.

The specific name means coast dweller, from the Greek word *aktes*, seashore. *A. aktites* is known only from the coast of northwestern Sinaloa and northwestern Sonora, where it is scattered along the mainland littoral and upon the adjacent sandy islands of Santa Maria and Lechuguilla, the latter taking its name from the local name for the plant. On Isla Lechuguilla, the plants were found upon the stationary dunes, scattered in colonies of small bluish rosettes with large round cabezas (fig. 59), the numerous leaves stiffly ascending, flat above, rounded below, and with flaring bases. The plants suckered out for 3–6 feet in the loose sand. My

guide, Carlos Preciado, stated that his people (Mayo Indians) had pit baked as many as 40–50 cabezas at one time on that island. They are sweet, well flavored, and superior to those of other agaves on the mainland. Some people had taken small plants from the island to plant about their houses on the mainland. The guide also stated that Isla Santa Maria had many more of this agave than Isla Lechuguilla. Analysis of the leaves of both island and mainland forms showed only negligible amounts of sapogenin.

***Agave schlechtendalii* Jacobi, Hamburger Garten-Blumenzeitung 20: 555. 1864.**

Of the many agaves named by Jacobi, *schlechtendalii* is the only one he attributed to Sonora, stating (loc. cit. 22:169. 1866.) that it was first introduced to Europe by the Botanical Garden in Gottingen. He described the leaves as 7–8 inches long and 2 inches wide in the middle. The plants were immature.

Berger wrote (*5*, p. *162*) that he had observed two forms of the plant Jacobi had reference to for several years in the Botanical Garden at La Mórtola. Berger described the leaves as 65 × 12–13 cm., but had not seen the plants flower. He thought the plant was related to *A. americana*.

I do not recognize this plant from Jacobi's or Berger's description, nor do I see any way of applying Jacobi's name to Sonoran or other agaves.

MANFREDA SALISB., GEN. PL. FRAGM. 78. 1866.

Low perennial herbs with fusiform succulent roots, fleshy underground stems or bulbous rootstocks, and short-lived, pliant, unarmed leaves in 1-several sessile rosettes; leaves without a terminal spine, the margins entire or finely serrulate, frequently crisped or undulate, weak, wholly green or spotted reddish or purplish, mostly reclinate; inflorescence spicate, the flowers mostly single, lax, proterandrous, the tube cylindrical, usually narrow and deep; segments equal or subequal, reflexed or outcurving at anthesis, green, yellow, to reddish or purple; filaments mostly long-exserted; anthers versatile; pistil long exserted, cylindrical, tubular, with a clavate, 3-lobed stigma; ovary fleshy, 3-celled; fruit an erect capsule, apically dehiscent; seeds numerous, flat, lunate or oblique, black. *M. virginica* (L.) Salisb.

The genus *Manfreda* was recognized by Rose, Trelease, and Small, but European horticulturists, including Berger, the monographer of *Agave*, combined it with *Agave* as a subgenus. American

floristic men have generally included it with *Agave*. The writer believes that this group of small herbs constitutes a natural generic group, separable from *Agave* by their unarmed, perennial, tender, reclinate leaves, bulbous leaf bases, fleshy underground stems, succulent fusiform roots, and lax spicate inflorescences. Some seedling agaves have succulent roots, but all adult plants examined have only wirelike roots about the base of the plant. These main roots later branch out into feeder rootlets. The flowers of *Manfreda* are quite variable. The longer tubular form with its mid-tube flexure, as in *M. virginica*, is quite different from any *Agave* flower, but some other *Manfreda* flowers with short tubes resemble flowers of some of the agaves. It is, therefore, the sum of the characters that distinguishes *Manfreda* from *Agave*. *Manfreda* is closely related to *Polianthes*, another herbaceous genus; see remarks on page 153.

The presence or absence of reddish spots on the leaves has been used for separation of species, but this character is generally valueless as a specific criterion. Many *Manfreda* populations show forms with or without leaf spotting and without other correlative characters for separating them. Leaf spotting appears to be a Mendelian character, segregating at random and representing a gene complex common to several species.

Flower tube much longer than the tepals, curved; filaments shortly exserted, not surpassing the tepals_____*M. singuliflora*

Flower tube shorter than the tepals, straight; filaments long-exserted, at least twice as long as the flowers.

Leaves long and narrow, about 1 cm. wide_____*M. jaliscana*

Leaves short and broad, 3–6 cm. wide_____*M. planifolia*

***Manfreda singuliflora* (S. Wats.) Rose. U.S. Natl. Herbarium Contrib. 8: 16. 1903.**

***Bravoa singuliflora* S. Wats., Amer. Acad. Arts Proc. 22: 479. 1887.**

Small sessile rosettes, perennial from tuberous bases and succulent roots; leaves few (4–8), reclinate, grasslike, linear, mostly 20–30 cm. long, 7–10 mm. wide, striate, with a thin, smooth or minutely denticulate, sometimes whitish margin; spikes 8–12 dm. tall, long-pedunculate, 8- to 10-flowered near apex; flowers single, purplish, remote, short-stipitate; ovary 8–10 mm. long at anthesis; tube very slender, about 30 mm. long, curving, gradually widened towards apex; tepals recurved at anthesis, 10–14 mm. long; filaments exserted 5–10 mm. beyond tube; anthers 7–8 mm. long;

pistil exserted 8–10 mm. after anther dehiscence; capsules orbicular, 15 mm. in diameter, short-stipitate, depressed at apex.

Type—*Pringle 1381,* mountains near Chihuahua City, Chihuahua, Aug. 19, 1887. There is one collection from the Chihuahua-Sonora border—Sierra Charuco, Rio Mayo, Oct. 1, 1936, *Gentry 2915,* on a rocky slope with pines. Other collections from adjacent Chihuahua indicate *Manfreda singuliflora* as widely and thinly scattered, associated with pine and oak on the higher slopes of the Sierra Madre mountains at elevations between 5,000 and 7,000 feet. There is little doubt that the plant occurs along the Sonoran side of the border in this habitat. It is not an abundant or conspicuous plant and may be overlooked.

M. singuliflora is distinguished from other manfredas by its very slender, long, curved, tubular flower and the bulbous underground base. It lacks the fleshy stem between the bulbous leaf base and the succulent roots common to many other manfredas. The filaments are much shorter than those in most species of the genus.

***Manfreda jaliscana* Rose, U.S. Natl. Herbarium Contrib. 7: 22. 1903.**

Low perennial herb, single or cespitose, with grasslike, reclinate leaves; leaves 40–60 cm. long, about 1 cm. wide, conduplicate, striate, green, smooth, with a narrow pale margin, fraying toward the tip; old dry leaf bases of other years persisting; spike 12–16 dm. tall, with lower bracts leaflike, the upper smaller, scarious, fragile; flowers terminal, lax, mostly single, greenish yellow (dried specimens); ovary 8–10 mm. long, fusiform; tube 7–8 mm. long, narrowly funnelform; tepals 10–11 mm. long; filaments 50–60 mm. long, purplish; anthers 8 mm. long; pistil exserted 50–60 mm.; capsules whitish, 12–15 mm. long, short-stipitate, truncate and short-apiculate.

Type—*Pringle 1850,* grassy slopes of the barranca near Guadalajara, Jalisco, December 1889. SONORA: Canyon Sapopa, Rio Mayo, on oak slope in rocks and grass, Feb. 8, 1935, *Gentry 1290* (fl., lf. & caps.); Curohui, Rio Mayo, in loose black loam of oak forest slope, alt. about 3,000 feet, Apr. 4, 1938, *Gentry 3640* (fl.). SINALOA: Mesa Malqueson, Cerro Colorado, rocky slopes on oak savanna, alt. 2,500 feet, Dec. 8, 1939, *Gentry 5183* (caps.). It occurs widely scattered on the deeper soils of the grassy oak slopes at elevations between 2,500 and 4,000 feet from southern Sonora to Jalisco.

Unless flowering, the plants may go unnoticed because they resemble clumps of grass. In Sonora and Sinaloa, the people call it

"mescalito," but gave me no special use for it. *M. jaliscana* appears to be endemic to the western slopes of the Sierra Madre Occidental.

***Manfreda planifolia* (S. Wats.) Rose, U.S. Natl. Herbarium Contrib. 7: 22. 1903.**

Agave planifolia Wats., Amer. Acad. Arts Proc. 22: 478. 1887.

Perennial rosette herbs with broad leaves; leaves mostly 10–20 cm. long, 3–6 cm. wide, ovate-lanceolate, fraying at the tips, broadly clasping at base, finely serrulate; spike 10–12 dm. tall with whitish, remote, scarious, triangular-apiculate bracts and 8–12 flowers in terminal ⅛ of shaft; flowers (dried) 30–45 mm. long; ovary broad, neckless, protruding into tube; tube short, broad, 8–9 mm. deep; tepals 15–20 mm. long, broadly linear, obtuse, reflexing at anthesis; filaments very long, 6–8 cm.; inserted 5–6 mm. above base of tube.

Type—*Pringle 1141*, warm sandy or gravelly banks near streams in canyons of the Mapula Mountains, Chihuahua, Oct. 19, 1886. SONORA: West slope of the Sierra Madre, east of San Bernardo, Rio Mayo, *Gentry xo*. Specimen consisting of a flower only, brought to camp by an "arriero" (muleteer) in oak woods country.

POLIANTHES L., SP. PL. 1: 316. 1753.

Small perennial herbs with succulent leaves on short bulbous stem; leaves radical, unarmed, seasonal; inflorescence bracteate, racemose, lax, the flowers zygomorphic, bisexual, commonly in pairs; perianth tube cylindrical to funnel-form, expanded above the middle, curved, much longer than the segments; stamens 6, included in perianth, inserted on sides of tube; anthers linear, erect, dorsifixed; ovary 3-locular; ovules numerous, flat, with a lax testa; fruit an ovoid capsule.

This is a small American genus, apparently endemic to Mexico, consisting of about 12 species. A sketchy account of them was provided by J. N. Rose in 1903 (U.S. Natl. Herbarium Contrib. 8: 8–14). There is still little material available for study. The genus *Polianthes* is closely related to the genus *Manfreda*, but the zygomorphic flowers with ampliate tubes and included vertical anthers appear to form a natural generic group to themselves. Shinners has recently submerged *Manfreda* under *Polianthes* (SIDA 2 (4): 333-338. 1966), along with several other closely allied genera, but before I can concurr, I would prefer to study

the various respective organs, both floral and vegetative, of these little known taxa.

***Polianthes tuberosa* L., Sp. Pl. 453. 1753.**

Rosette herb with green, succulent but thin, outcurving leaves, 30–45 cm. long, linear-lanceolate, channeled below, plane above, frequently brown-spotted on the back, margins smooth; inflorescence laxly spicate, 6–9 dm. tall with leaflike bracts on the peduncle; flowers geminate, waxy white, 3.5–6 cm. long; segments much shorter than the tube, spreading, oblong-lanceolate; filaments 4–5 mm. long, included, inserted on upper part of tube; flowers strongly fragrant.

The plant is known only as a cultigen and its origin is generally regarded as Mexico, where it is called "nardo." The English name is tuberose. It is now cultivated for cut flowers in many parts of the world with more benign climates, as it is only "half-hardy." Judging by the great masses of nardo flowers seen in the markets of Mexico on fiesta days, it must be very popular as a cut flower. They have good lasting qualities and a penetrating fragrance. They have been observed in the markets of the larger Sonoran towns, having been shipped in from the south. They may be locally cultivated in Sonora, although I find nothing in my notes to that effect.

YUCCA L., SP. PL. 319. 1753.

Acaulescent or arborescent perennials with a simple or branched caudex crowned by a rosette of spirally arranged leaves; leaves pliant or rigid, pungently tipped, denticulate-serrulate or with filiferous margins or the margin entire; inflorescence a large panicle borne in the upper axils of the rosettes, rarely apical; flowers open-campanulate to globose with incurved tepals; tepals 6, whitish or frequently purple-tinged, subequal, connate towards base or distinct, fleshy tender; stamens 6, inserted on an annular nectary or on base of petals; the filaments enlarged apically, puberulent, the anthers small, sagitate, close and eccentrally affixed; stigma sessile or on a short style, 6-lobed; ovary superior, 3-locular, with numerous ovules; fruit a loculicidally dehiscent capsule or indehiscent, dry and spongy or baccate; seeds black, flat and thin or thick, or rounded, rugose or finely wrinkled.

Fruit dehiscent, drying as a persistent capsule; leaves less than 1.5 cm. wide, flexible ---------- *elata*, below.
Fruit fleshy, indehiscent; leaves 2–6 cm. wide, stiffer.

Flowers 20–40 mm. long, broader than long; ovary short, thick, about 25 mm. long including the pistil; leaves thin, pliant; plants mostly simple.

Plants surculose, in maturity 3–5 m. tall; leaves 3.5–5 cm. wide, the margin smooth, filiferous; filaments pubescent ---------- *schottii*, p. 157.

Plants nonsurculose, 1–2 m. tall; leaves 2–3 cm. wide; margin nonfiliferous, serrulate; filaments glabrous below the apical knob ---------- *madrensis*, p. 159.

Flowers 50–100 mm. long; ovary long and tapering, 40–65 mm. long; leaves thicker, stiffer, frequently wider; plants usually developing several trunks.

Large plants branching in the crown; leaves 70–140 × 4–5 cm.; flowers subsessile, erect or divergent; branches of the inflorescence pubescent ---------- *grandiflora*, p. 162.

Plants not branching in the crown; leaves 60–80 × 3–4 cm.; flowers pedicellate, nodding; branches of the inflorescence glabrous ---------- *arizonica*, p. 166.

Yucca elata Engelm., Bot. Gaz. Crawfordsville 7: 17. 1882.

***Yucca angustifolia* var. *radiosa* Engelm. ex King, U.S. Geol. Exploration 40th Parallel Rpt. 5: 496. 1871.**

***Y. angustifolia* var. *elata* Engelm., Acad. Sci. St. Louis Trans. (1873) 3: 50. 1878.**

***Y. radiosa* (Engelm.) Trel., Mo. Bot. Gard. Ann. Rpt. 13: 56. 1902.**

Short to medium arborescent plants, mostly 1–3 m. tall, the older frequently 1- to 3-breached in the crown, and closely surculose forming clumps; rosettes symmetrical, large; leaves numerous, narrowly linear, the blades mostly 40–70 × 0.8–1.5 cm., planoconvex, rounded below, striate, pale green, pliant, divergent, finally reflexing and persisting dry on the trunk; margin white, finely filiferous; inflorescence a diffuse ellipsoidal panicle, 1.5–2 m. long, the peduncle relatively slender and greatly exceeding the leaf crown; flowers creamy white or tinged with green or pink; tepals subequal, generally 35–50 × 15–25 mm., the inner broader,

PN-2165

FIGURE 60.—*Yucca elata* on the Campbell Avenue Farm, University of Arizona, Feb. 1, 1957. Original seedlings were from greenhouse in 1939.

elliptical or ovate, acute; filaments mostly 18–25 mm. long; slender; pistil 22–30 mm. long; ovary about 8 mm. diameter, oblong-cylindrical with deep carpel sutures, abruptly terminating in style; style 7–10 mm. long, shape variable; capsules smooth whitish, regularly oblong, 5–6.5 × 3–4 cm., the wall rather thin; seeds 7–10 × 9–14 mm., thin, dull black, with broad marginal wing (partly from (*57*)).

Type—Engelmann did not specify a type specimen. However, McKelvey, (*33*) nominated as lectotype *Rothrock 382*, U.S. Natl. Herbarium No. 35891, collected in 1874 near Camp Grant, Graham County, Arizona. This species commonly occurs on sandy and gravelly soils at elevations between 1,500 and 6,000 feet from Pecos County, Texas, to western Arizona and adjacent Mexico. I have been unable to locate a specimen from Sonora. However,

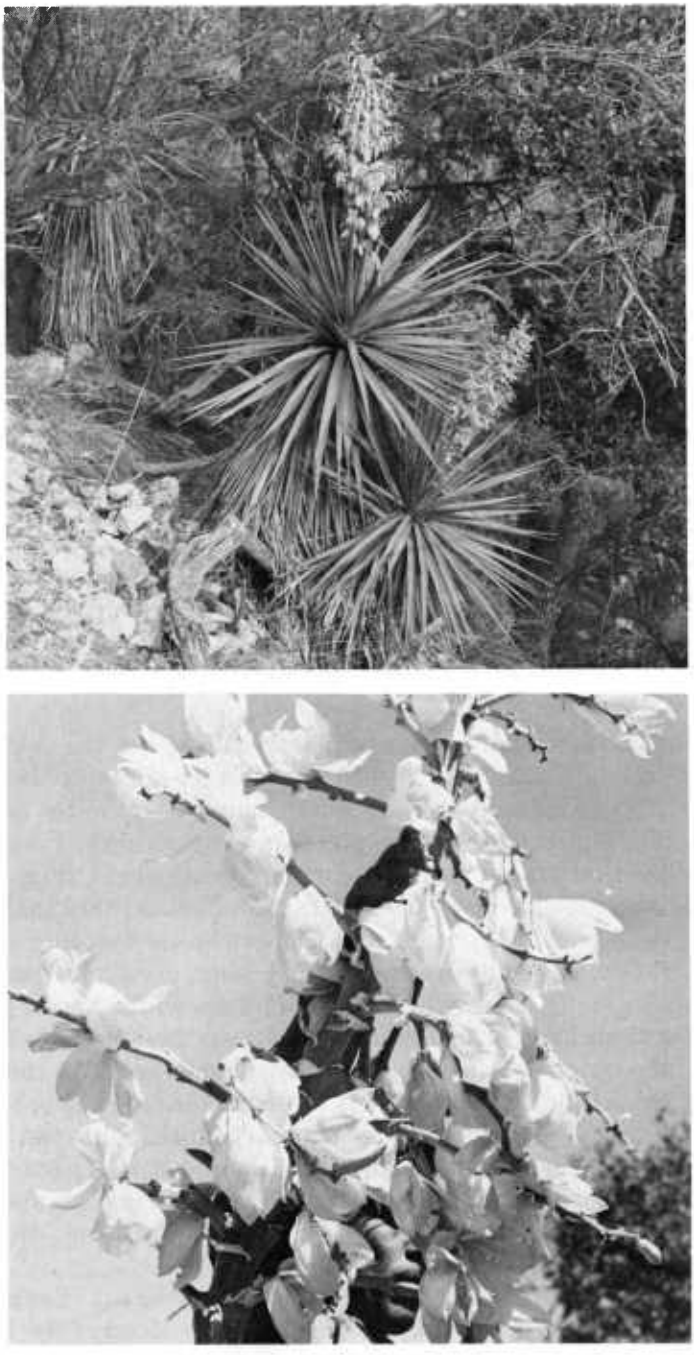
since *Y. elata* is well documented along the Sonoran border region in Arizona and northern Chihuahua, there is little doubt it exists in adjacent Sonora.

Y. elata is easily recognized in its native range by its elegant crown of narrow, flexible, finely filiferous leaves with a thin white margin on well-developed trunks. No other dry-fruited yucca is known to occur in Sonora. Figure 60 shows a group cultivated at the University of Arizona, Campbell Avenue farm, in Tucson. The original seedlings were transplanted from the greenhouse in 1939. The photograph was taken Feb. 1, 1957, so the plants, the tallest of which are over 6 feet, are 18 years old. This provides an idea of bulk growth under these arid conditions (average annual rainfall 12–14 inches). The uneveness of growth probably reflects the genetic variability so common in wild sexual populations. Wild stands have been employed as cattle feed, for making paper, for jute-class fiber, and for a detergent soap. (See p. 12.) Kearney and Peebles (*30*) reported the "Indians eat the young flower stalks and lower portion of the stem." Who will be the first to collect and document this plant in Sonora?

***Yucca schottii* Engelm., Acad. Sci. St. Louis Trans. (1873) 3: 46. 1878.**

Plants at first simple, eventually surculose, the trunk short or to 3–5 m. tall, rarely branched; the rosettes deeply leaved on young plants, reduced on old; leaves numerous, mostly 50–80 × 3.5–5 cm., bluish green, thin, pliant, mostly straightly ascending to declined on trunk, rarely recurving, the margin thin, brown, friable and exfoliating in age, sparsely filiferous; terminal spines small, 5–15 mm. long, weak, reddish brown or fuscous; panicles short, rarely exceeding leaves, 5–8 dm. long, erect, the rachis and branches usually densely tomentose; flowers white, small, globose, broader than long, truncate at base; tepals 20–40 × 10–20 mm., ovate, the outer brownish mucronate; filaments 14–18 mm. long, pubescent, outflexed and swollen towards apex; anthers 3–4 mm. long, closely and eccentrally fixed; ovary thick, with pistil about 25 mm. long, abruptly tapering to a 6-lobate stigma; fruit (dry) 60–125 × 25–38 mm., rounded at base, tapering at apex, frequently irregularly constricted; seeds 5–8 × 7–10 mm., thick, flat or rounded, black, rough.

Type—Mo. Bot. Gard. 135692. Sierra west of Santa Cruz County, Arizona. SONORA: El Rancho Roble (loop of the Bavispe River), northeast of El Tigre, Sept. 2–13, 1941, *White 4217* (lf. & fr.); Canyon de la Escalera, oak grassland, Aug. 3, 1940, *White*



PN–2166, PN–2167

FIGURE 61.—*Upper, Yucca schottii* in Huachuca Mountains, Arizona; *lower, Yucca grandiflora* showing large, divergent, subsessile flowers of the type.

3128; 21.4 km. north of Nacozari in oak woodland, July 22, 1960, *Felger 3593*. On rocky volcanic and limestone slopes at elevations between 4,000 and 5,000 feet in oak woodland and pine-oak forests in southeastern Sonora and adjacent areas in Arizona, New Mexico, and Chihuahua. (Fig. 61, *upper.*)

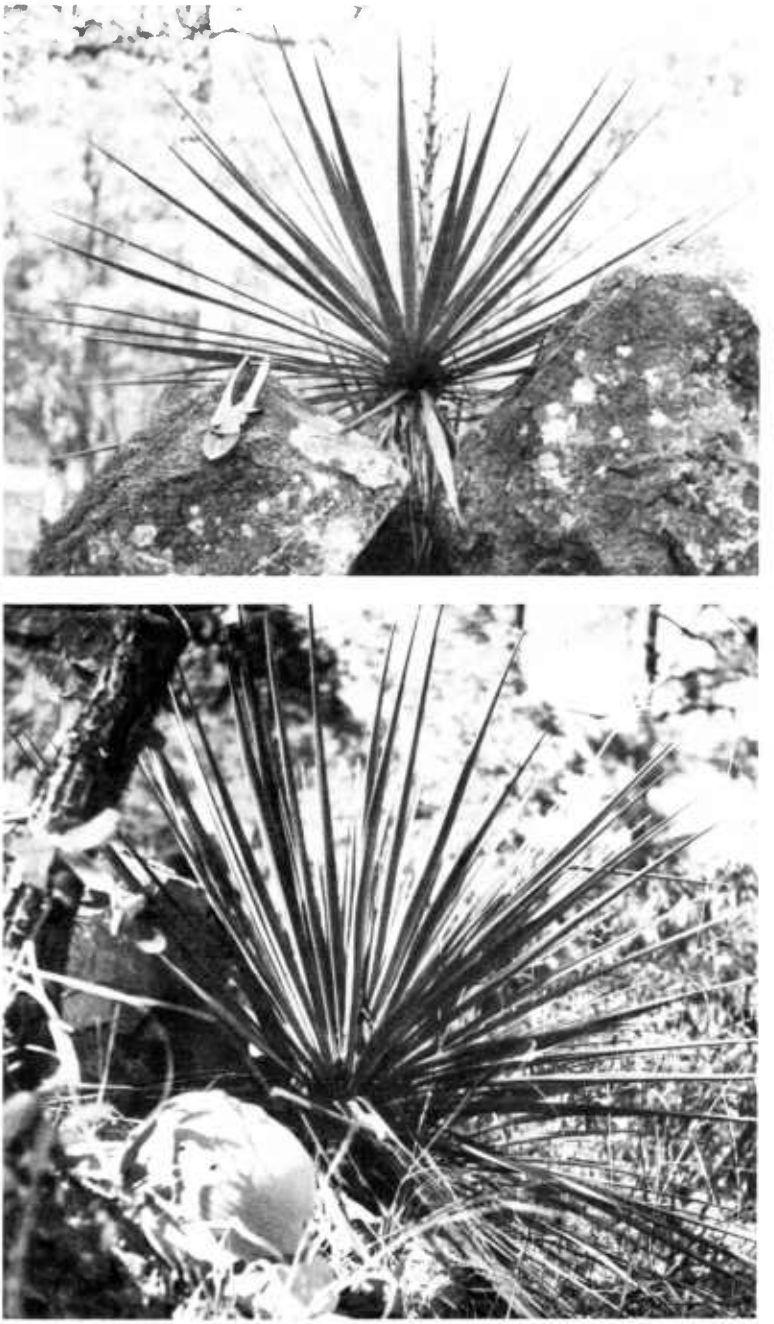
Y. schottii is distinguished by its short inflorescence with small flowers on tomentose branches, pliant, light bluish-green leaves, and summer-flowering habit. It shares these characters with *Y. madrensis,* but the latter has serrulate leaf margins, narrower leaves, and a simple, shorter habit. *Y. schottii* is not known to intergrade with other fleshy-fruited species although they occur sympatrically. This may be attributable to the spring flowering of related species and the summer flowering of *Y. schottii*. Kearney and Peebles (*30*) regarded it as, "A large handsome species, often cultivated."

***Yucca madrensis* Gentry, sp. nov.** **Figure 62**

Stem simple, short, rarely to 2 m. tall, terminated by a thin open rosette; leaves mostly 50–100 × 2–3.5 cm., linear-lanceolate, thin, flexible, straight to reflexing in age, nearly plane to slightly conduplicate, bluish glaucous green to yellowish green, smooth-striate above and below, the margins not filiferous, serrulate with a thin brown and grayish border; spine 5–12 mm. long, weak, subulate, brown to gray; panicle short, not exceeding the leaves, the central rachis stout, tapering, sparsely pubescent along sutures near the branch axils, the branches short, the longer in midpanicle 6–8 cm. long, ascending, pubescent; flowers white, small, about 35 mm. long; outer tepals lanceolate, 30 × 10 mm., inner tepals ovate-lanceolate, 30 × 12–14 mm.; stamens 15 mm. long, the filaments glabrous below the swollen flexuous apex; ovary 25 mm. long, the 6–lobate papillate pistil on a short beak; fruit unknown.

Type—*Gentry 21209,* Sierra Charuco, along the Sonora-Chihuahua boundary, Mexico, in pine-oak forest, alt. 4,500–5,000 feet, Sept. 9, 1965 (lf. & old dried inflorescence), deposited in U.S. Natl. Herbarium, No. 2557499. Same locality: Upper Sonoran oak canyon slope, July 23, 1936, *Gentry 2304* (flower description

Planta simplex brevicaula, 1–2 m. alta; folia 50–100 cm. longa 2–3.5 cm. medio lata, linearo-lanceolata, palido-viridia flexila, margine brunneo-grisea serrulata; spina terminali debila subulata, 5–12 mm. longa; inflorescentia paniculata, ramis lateralibus pubescentibus ad 6–8 cm. longa en medio inflorescentia; perianthemum album ca. 35 mm. longum, segmentis inaequalibus lanceolatis vel ovato-lanceolatis, ca. 30 mm. longis; filamenta 15 mm. longa glabra infra apicem clavata; ovarium cylindricum 25 mm. longum; stylus breviter 6-lobatum; fructum non vidi.



PN–2168, PN–2169

FIGURE 62.—*Yucca madrensis* on Sierra Charuco: *Upper*, Note thick base of dry persisting inflorescence. Type specimen was made of this plant; *lower*, younger long-leaved plant.

drawn from this number); high rocky rims around Arroyo Hondo, alt. 5,000 to 5,500 feet, Mar. 6 and 7, 1951, *Gentry 10242* (lf. only). SONORA: Sierra Murrieta above Toribusi, 15 miles west of Bacanora, oak woodland, limestone, alt. about 4,500 feet, May 17, 1957, *Gentry 16630*. A rarely observed plant on rocky slopes at elevations between 4,000 and 5,500 feet in oak woodland and pine forests, southeastern Sonora and adjacent Chihuahua.

This rare yucca, named after the Sierra Madre which it inhabits, cannot be certainly placed in section until the fruits are known. It resembles *Y. schotti* with its small flowers and flexible slender leaves. However, none of the fleshy-fruited yuccas, section Sarcocarpa, have leaves with serrulate margins. Several of the dry-fruited yuccas, section Chaenocarpa have serrulate leaf margins. The Sierra Charuco plants were originally reported (*13*) as *Y. rigida* Engelm., which is a long-trunked, stiff-leaved xerophyte of the Coahuilan Desert. Other than the serrulate leaf margins, there is little to support placing the Charucan plants in that species. The Sierra Murrieta specimens are serrulate along only the upper margins of the leaves. This, together with the more friable nature of the margin, suggests an infusion of genes from *Y. schottii*. *Y. madrensis*, because of the similarities in inflorescence and thin, flexuous leaves, appears to form an alliance with *Y. schottii* to the north and *Y. jaliscensis* Trel. to the south.

Trelease did not cite a type specimen for *Y. jaliscensis* (Contrib. U.S. Natl. Herbarium 23: 92. 1920.), only "Jalisco; type from Zapotlan." However, in his earlier account of *Y. schottii jaliscensis* Trel. Mo. Bot. Gard. (Ann. Rpt. 13: 99. 1902.), he mentions Pringle's collection from Zapotlan. The type of *Y. jaliscensis* Trel., therefore, should be taken as *Pringle 4392*, collected in "Valley Zapotlan, Jalisco, Mexico, 13 May 1893. Tree-like 15–25 feet." It is a good specimen with leaf and flower. Duplicates of this collection are doubtless in many herbaria, as Pringle collected in large sets.

The name given to *Y. madrensis* by the mountain people is usually "soco." The roots were reported as used for soap and the tender, green fruits as eaten by the Warihio Indians. Analyses of the leaves by the U.S. Department of Agriculture (*53, 54*) showed about 0.025 percent sapogenin in the leaves and 1.5 percent smilogenin in the roots, which identifies the Indian soap chemically. The plant forms a low, rather bluish-leaved, ornamental rosette. Sometimes the leaves are unusually long and somewhat arching. As with other yuccas, the leaves on the more elongate old stems are smaller than leaves on young vigorous plants. *Y. madrensis* flowers in summer along with the rains.

Yucca grandiflora **Gentry, Madroño 14: 51–53. 1957.**

Arborescent, 4–6 m. tall, branching from the base and toward the crown, with deep leaf crowns; leaves 70–100 cm. long, to 140 cm. on vigorous young plants, 4–5 cm. wide in the midblade, slightly narrowed above base, dark green, smooth, ascending to descending, persisting dry and deflected in age on the trunk, the margin narrow, brown, exfoliating on dried specimens, the terminal spine stout, brown or chestnut, broadly grooved; inflorescence an irregular open panicle, erect or deflexed, 70–100 cm. long; peduncle 10–30 cm. long, glabrate below; bracts and bractlets scarious, dull white, friable; lateral branches densely white-tomentose, flexuous, horizontal or openly angled from the central rachis; flowers short-pedicellate to subsessile, glabrous, creamy white, divergent, large; perianth 6–9 cm. long, the segments spreading, ovate, thin, bluntly mucronate, connate at base, the outer slightly smaller and thicker than the inner; filaments hyaline pubescent throughout, 45–48 mm. long, flexed and swollen apically, anthers 5 mm. long, closely affixed, oblong; ovary elongate, 45–60 mm. long, the style forming a short beak with deeply lobate stigma; fruit large, fleshy.

Type—*Gentry 11601,* above Tierra Negra, Cedros Range, east of Rio Cedros, Sonora, Feb. 14, 1952, U.S. Natl. Herbarium No. 2089433 and No. 2089434 (fig. 61, *lower).* SONORA: Sierra de la Ventana, west side of higher peaks, Rancho Guacoporo, May 27, 1965, *Gentry & Gonzales 21181;* 3 miles south of Huachinera, alt. 4,100 feet, Oct. 4, 1965, *Hastings & Turner 65–55* (lf. & fr.); 21.4 km. north of Nacozari, *Felger 3594* in foothills with oak woodland; vicinity of Rancho San Isidro, canyon de Rio Zatache, alt. 2,930 ft., *Felger & Marshall 3337,* "trunk ca. 10 ft." Tentatively assigned here also from 15 miles south of Bacanora in mountain pass, May 16, 1957, *Gentry 16615.* On grassy slopes in open woodland, usually with oaks, alt. 2,000 to 4,500 feet on volcanic and limestone rocks, through southeastern Sonora.

Yucca grandiflora shows a close relationship to *Y. arizonica* in its arborescent habit and large flowers and fruits (fig. 63). Among the rather many characters that separate it from *Y. arizonica* are the high-branching trunks, the open ragged inflorescence, frequently declined, with densely pubescent rachises, subsessile vs. long-pedicellate flowers, and erect or divergent flowers vs. nodding flowers. The leaf of *Y. grandiflora* is wider, thinner, and more flexible than that of *Y. arizonica.* Except for the arborescent habit and pubescent inflorescence, there is little similarity between *Y.*

PN–2170

FIGURE 63.—*Yucca grandiflora* south of Bacanora; large succulent fruits.

grandiflora and *Y. schottii,* its nearest geographic neighbor, which generally occupies higher elevations in the mountains.

The large yucca population about Bacanora is doubtfully assigned here to *Y. grandiflora.* (See figure 64.) The glabrate branches and strong pedicels of the inflorescence are more like those of *Y. arizonica,* but the treelike form and large, declined, ragged panicles are more like *Y. grandiflora.* It appears probable that an exchange of genes has occurred in this area. The population as a whole consistently resembles *Y. grandiflora.* Rather than attempt subspecific or other definition without more material evidence, it seems prudent to do no more than point out the problem at this writing.

Y. grandiflora in the Rio Mayo country is called "sahuiliqui," the Spanish spelling of the Warihio name for the plant. Some Mexicans, including those at Bacanora, call it "datil," a common misnomer for yuccas in the state. Some of the rancheros about Bacanora expressed a liking for the sweet fruits, saying they were even better when roasted than raw. I ate them when hungry, but was soon satiated, as with a bar of candy. Some of these fruits reach very large size, 8 inches long and 2 inches in diameter and estimated to weigh about 2 pounds (fig. 63). They are quite bitter until fully ripe, when the thick flesh all about the seed core becomes soft. The seeds fill the cells irregularly, many of them undeveloped, apparently for lack of the pollen gamete. When seeds are remote along the cells, they grow very thick, being about round. Where they grow closely packed, they are strongly flattened as is typical of seeds of the Agavaceae, but large and thick like all seeds of the fleshy-fruited yuccas.

Y. grandiflora is not a common plant. Other than the localities cited above, I remember it only from the Sierra Murrieta, west of Sahuarita. "Sahuiliqui," however, is also reported to grow near Jecopaco within the state of Chihuahua in the upper Mayo River country. The mountain pass south of Bacanora along the road to Tonichi has many fine examples of this handsome plant. The flowering season is spring; in the Rio Cedros country *Y. grandiflora* was in early flower in middle February. Around Bacanora, farther north, the last flowers and ripening fruits were found in mid–May. On Sierra de la Ventana only dried flowers were found in late May.

PN-2171

FIGURE 64.—*Yucca grandiflora* south of Bacanora; old plants of a typical population discussed on page 164.

Yucca arizonica **McKelvey, Arnold Arboretum Jour. 16: 270. 1935.**
Figure 65

Aborescent, commonly forming clumps with unbranched trunks up to 3 m. tall; leaves mostly 60–80 × 3–4 cm. thick, straight, deflexing and persistent on trunks, concave above, convex below, light green to yellowish green, with a thin, brown, smooth margin, rarely exfoliating, and a light reddish to gray terminal spine 1–1.5 cm. long; panicle 5–10 dm. long, erect, the flowers borne above the apical leaves, long obovoid in outline, the laterals strong and spreading; rachises glabrous; flowers mostly 60–100 mm. long, long-pedicellate, creamy white, not expanding, campanulate, the bracts and buds frequently purple-tinged; tepals lanceolate, 70–60 × 24–22 mm., acute, firm; filaments pubescent, about 35–40 mm. long; ovary long, narrow, 40–45 × 4–6 mm., with a tapering style 5–6 mm. long; fruit 15–20 × 4–6 cm., mostly oblong, short or longbeaked; flesh sweet and edible when ripe; seeds large, thick, flat, dull black.

Type—"Probably near Nogales, Ariz., Mo. Bot. Gard. No. 135693" (*56*). SONORA: 3 miles north of Rancho Tinaja, near El Datil, Feb. 27, 1951, *Gentry 10215;* about 5 miles northeast of El Datil, Altar District, Mar. 22, 1952, *Gentry & Fox 11628;* 6–7 miles north of Matapé, Nov. 4, 1958, *Gentry & Arguelles 17619* (lf.); talus slope of basaltic cliff toward south end of Baviso Mountains, 17 miles southeast of Magdalena, Sept. 11, 1934, *Wiggins 7134* (lf. & fl.); Barranca 13 miles south of Divisadero, elevation 1,880 feet, Sept. 25, 1934, *Wiggins 7464 B;* 21.8 miles east of Puerto Libertad, alt. 1,550 feet, Feb. 20, 1965, *Hastings & Turner 65–17* (lf. & fl.); south end of Baviso Mountains, 17 miles southeast of Magdalena, Sept. 11, 1934, *Wiggins 7134* (lf. & fl.); same locality, *Shreve 6638;* crossroads about 22 miles southeast of La Union, *Felger & Gentry 7850;* 16.4 miles northeast of Mazucahui along road to Moctezuma, alt. about 2,950 feet, June 11, 1960, *Felger & Marshall 3348* (lf. & fr.); about 15 miles southeast of Magdalena on road to Cucurpe, *Felger 7944;* Rancho San Gorge (northwest of Hermosillo), alt. about 2,700 feet, *Felger & Russell 6902.* Generally ranges at elevations between 1,000 and 4,500 feet on grassy slopes and along arroyos in the upper desert in southern Arizona and northern Sonora.

The Sonoran plants are generally taller and in smaller clumps than those observed in the populations of southern Arizona. The latter are commonly only 1 to 2 m. tall, appearing relatively stunted, due perhaps to the higher elevations and shorter growing season. On the granodioritic hills near El Datil, *Y. arizonica* was

PN–2172, PN–2173

FIGURE 65.—*Yucca arizonica* in northwestern Sonora: *Upper*, short-stemmed clone or colony; *lower*, tall clone near Rancho Datil.

associated with *Cercidium* ("palo verde"), *Carnegiea* ("saguaro"), *Olneya* ("palo tésota"), and *Fouquieria* ("ocotillo").

In Sonora, this species is usually recognizable by its long, narrow, rather stiff leaves and tall, unbranching trunks (fig. 11). The long, narrow tepals and glabrous floral rachises distinguish it further from its arborescent neighbors, *Y. schottii* and *Y. grandiflora.* The plants noted were always scattered; no dense populations were observed.

Weber (*57*) in southeastern Arizona found intergrading characters between *Y. arizonica* and *Y. baccata* and interpreted this as hybridization. Out of this complex McKelvey (*33*) earlier had separated *Y. thornberi* and *Y. confinis,* distinguished by the characters acaulescent vs. caulescent and the angle of the filament tip at anthesis. Weber found these characters undefining and recognized the two taxa as hybrids. He mentions the "typical blue form" character of the leaves for identifying populations to be associated with *Y. arizonica.* This hybridization has not been observed in Sonora where all populations seen are outside the natural range of *Y. baccata.*

However, in the locality around Bacanora in eastern Sonora, an extensive population of a tree yucca shows affinities to *Y. arizonica* and *grandiflora.* This Bacanora population resembles the former in its smaller flowers and nearly glabrous inflorescences, and resembles the latter in its larger size, stem branching, larger, more pliant leaves, and declined panicles. Both McKelvey's and Weber's painstaking studies illustrate the striking difficulties in the taxonomy of these genetically promiscuous plants. The Sonoran members are no exception and an adequate concept of relationships still depends upon detailed field population studies.

In Sonora, *Y. arizonica* is called "datil" and the name Rancho Datil commemorates its presence there. The sugary ripe fruits of *Y. arizonica* may grow up to 6–8 inches long and are eaten by the local inhabitants. The remarks of Bell and Castetter (*3*) regarding food use of the yucca by the Papago Indians are generally more applicable to this species than to *Y. baccata* Engelm. The latter scarcely occurs in the Papago territory, wheras *Y. arizonica* is common through their mountains. Bell and Castetter were apparently unaware of McKelvey's species when writing their treatise.

Bird peckings have been observed in the ripe fruits of *Y. arizonica.* Insect larvae, presumably of the Pronuba moths, frequently bore through the seeds, leaving but a small percentage of viable seeds. Because of these and other environmental hazards, only a minute

fraction of any given sexual generation ever matures beyond the seeding stage, perhaps one seed in a million. Young plants are always rare. Weber (*57*) gives 6 years and 1 month as the earliest age at which *Y. arizonica* flowered from seed planting. In nature, the plants do not flower every year because inflorescence apparently depends upon favorable rains. The plants are very long lived and Weber reasons about their age as follows: "*Y. arizonica* occasionally produces stems 2.4 m. tall (Sonoran plants commonly reach this height). The annual growth rate of seedling stems in this species was shown to be 0.27 cm. Based upon these measurements, (for 6-year period) the older stems of *Y. arizonica* would approximate 880 years old." Clumps of this yucca, which gradually build out by rhizomatous offsets, may represent a generation more than a thousand years old.

Several analyses of the leaves of *Y. arizonica* for sapogenin content were as follows: from El Datil, 0.95 percent and 1.1 percent sarsapogenin; from Nogales, 0.25 percent; and from near Ruby, Ariz., 0.0 percent. Analysis of the seeds showed 28.4 percent oil and 14.4 percent protein (*53–56*).

Yucca sp.

A rare *Yucca* was collected in sterile condition on Sierra Charuco, Mar. 7, 1951, *Gentry 10250, 10247* (fig. 66). The plant had a short, simple trunk and a small crown of divergent, yellowish-green leaves. The leaves have a smooth, glossy surface, unlike any other *Yucca* known to me. It reminds me of another colony of yuccas that occupied the top of Sierra Orejon when I climbed that peak in the winter of 1934–35. The Rio Mayo skirts the foot of Sierra Orejon, which rises steeply as an isolated peak in the Rio Mayo Valley about where the Sonora-Chihuahua boundary crosses the Rio Mayo. The Warihio Indians told me the plants bore large fruits like bananas, but sweeter, which they ate (*15*). It is probably an undescribed species and botanists in the region should try to collect it.

HESPERALOE ENGELM. EX. WATS. EX KING, U.S. GEOL. EXPLORATION 40TH PARALLEL RPT. 5: 497. 1871.

Cespitose perennials with bulbous fibrous bases forming grass-like clumps; leaves succulent, linear elongate, fibrous, with narrow filiferous margins and graying tips; inflorescence racemose to paniculate, the flowers in indeterminate clusters on unequal pedicels; flowers stipitate, nonsequential, 6–merous, narrowly campanulate with connivent tepals; tepals with fleshy keel, about

PN-2174

FIGURE 66.—Anonymous species of *Yucca* on Sierra Charuco.

equal, essentially free but united on a fleshy nectariferous receptacle; filaments inserted on receptacle or adnate to base of tepals; anthers dorsifixed, sagitate, introrse, included in perianth; ovary ovoid to oblong, trigonous, 3–celled; ovules numerous in 6 ranks; style elongate but included in perianth; stigma papillate, perforate; fruit a dehiscent capsule, stipitate, beaked, transversely rugose, persistent; seeds large, lunate, thin, flat, black; cotyledon arched in germination.

A small genus of northern Mexico and adjacent United States, consisting of three species. *Hesperaloe nocturna* Gentry is known only from Sonora. *H. parviflora* (Torr.) Coult. occurs in Texas and *H. funifera* (Koch) Trel. in northeastern Mexico. The strong fibers of *H. funifera* are used locally for cordage, while *H. parviflora* is in ornamental culture in Texas. Trelease gave a historical account of these two species in 1902 (*46*). The following synoptical key shows some contrasting characters of the three species and identifies our Sonoran subject, *H. nocturna.*

Leaves large and coarse, 3–6 cm. wide near the base and to 2 m. long, nearly straight, with coarse white marginal threads; flowers greenish tinged with purple ---------- *funifera*

Leaves smaller, 1–3 cm. wide near base and 1–1.5 m. long, arcuately spreading, with very fine marginal threads.

> Flowers diurnal, dark red to light red, tubeless; tepals appressed at anthesis; filaments elongate (13–14 mm.) with small anthers (4 mm.); ovary small (4–5 mm. long), ovoid, free of receptacle; style elongate (12–13 mm.), slender. *parviflora*
>
> Flowers nocturnal, greenish lavender, with a short tube; tepals reflexed at anthesis; filaments short (8–9 mm.) with large anthers (8–9 mm.); ovary large (8–9 mm. long), oblong, imbedded in receptacle; style short (8 mm.), stout. *nocturna*

Hesperaloe nocturna **Gentry, Madroño 19: 74. 1967. Figure 67**

Acaulescent, densely cespitose rosettes forming large clumps about 1.5 m. tall and 1–2 broad; leaves narrowly linear, 1–1.5 m. long, 1–2 cm. broad near the base, striate, plane towards the base and deeply concave upwards on the upper side, deeply rounded below, tip acicular and pungent, fraying in age; margin narrow, brown, irregularly and finely filiferous; inflorescence slender, 1.5–2 m. tall, a simple or 2- to 3-branched arching raceme on long

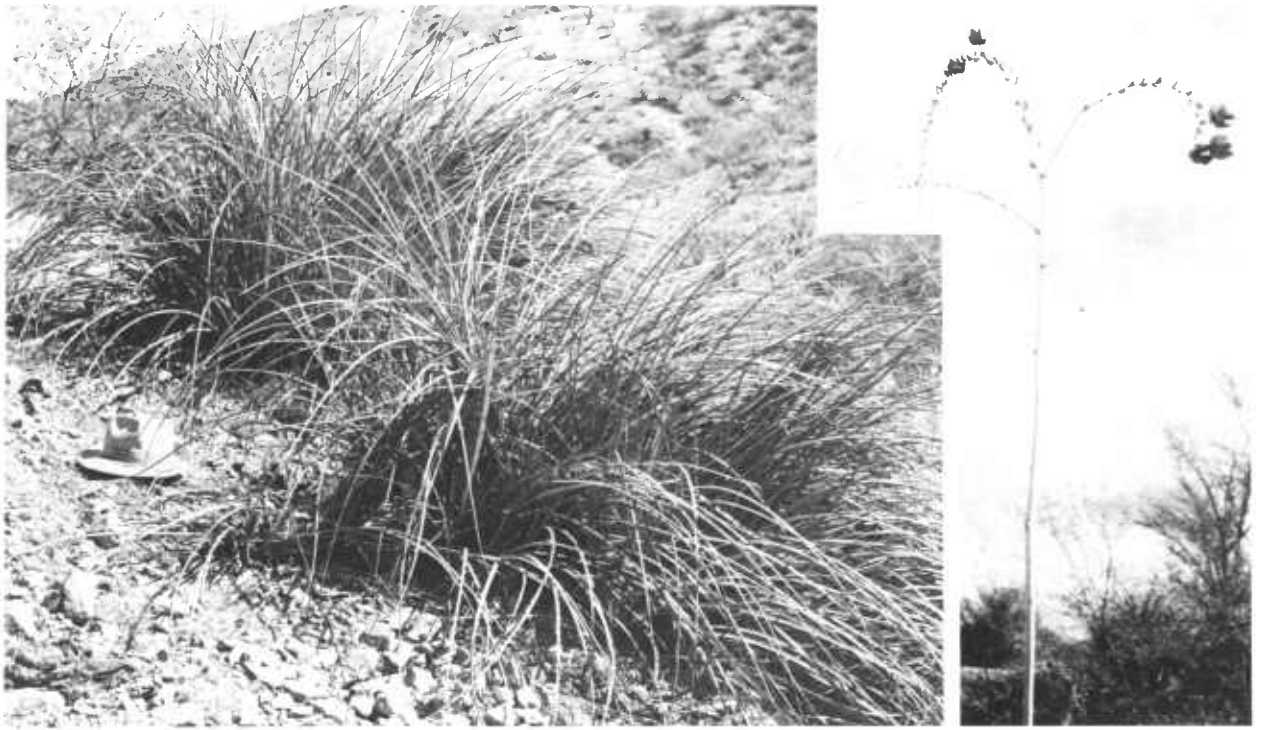
FIGURE 67.—*Hesperaloe nocturna* with flower *(N)* compared with flower and inflorescence section of *H. parviflora (P)*.

peduncles; bracts of the peduncle dry, lanceolate, 6–4 cm. or less long; bracteoles chartaceous, 3–5 mm. long, obtuse to acute; flowers 24–30 mm. long, fasciculate on unequal pedicels 5–18 mm. long, 4–6 or 8 at the node, noctural, pruinose pink to lavender in the bud, greenish below, stipitate on a pedicellar joint; tube 2–3 mm. long; tepals 15–22 mm. long, reflexing at nocturnal anthesis, other times appressed, whitish within, the outer tepals pink or lavender on the back and narrower than the inner, the inner with a broad flat keel and greenish pink or greenish lavender on the back; filaments equaling the pistil, 8–9 mm. long, attached to base of tepals; anthers sagitate, versatile, 8–9 mm. long; ovary 8–9 mm. long above tube base, green, trigonous, oblong, roundly angled at the apex, ringed at the base with nectary; style 8 mm. long, stout, stigma capitate, papillate; capsules depressed ovoid or oblong, 3–4 cm. long, 2.5–4.5 cm. broad, apiculate, rugose; seeds large, black, 8 × 11 mm.

Type—*Gentry & Felger 19988*, 15 miles southeast of Magdalena along road to Cucurpe, by Sierra Baviso, Sonora, Mexico, alt. 3,200 to 3,500 feet, May 21, 1963, deposited in U.S. Natl. Herbarium, No. 2503567. Also at the type locality: *Gentry 19890*, Apr. 1 (sterile); *Felger 3458*, July 16, 1960. Talus slope of basaltic cliff toward south end of Baviso Mountains, 17 miles southeast of Magdalena, Sept. 11, 1934, *Wiggins 7132* (lf. & cap.). The description of the flowers was made with fresh material; dried flowers are smaller.

In both *H. nocturna* and *H. parviflora*, the flowers appear one by one at any given node, so there is little apparent progression up or down the raceme. The strictly noctural flowering of *H. nocturna* is of particular importance in separating it from the other two species with diurnal flowers. Speculatively, the reflexing of the tepals with their whitish interior are correlative to pollination by night-flying insects; while the red, tubular form of the diurnal flower is probably correlative to pollination by birds. Other structures, such as the large nocturnal anthers and the small diurnal anthers, may also reflect biotic adaptations.

H. nocturna is patently rare; it is not known from other collections or places. However, since much of northeastern Sonora has not been botanized, it may be expected in other Sonoran localities. The Sonoran collections record the genus from west of the continental divide. In appearance, the plants closely resemble the clumped "bear grass," *Nolina microcarpa*, which occurs in the same region. The habit of *Hesperaloe nocturna* in figure 68 can be compared with that of *N. microcarpa* in figure 72, page 183.



PN–2175

FIGURE 68.—*Hesperaloe nocturna* in natural habitat. Large clumps look like "bear grass," *Nolina microcarpa*, but large capsules *(right)* are characteristic of genus *Hesperaloe*.

Transplants of *H. nocturna* have responded well in Nogales and in the Desert Botanical Garden near Phoenix, Ariz.

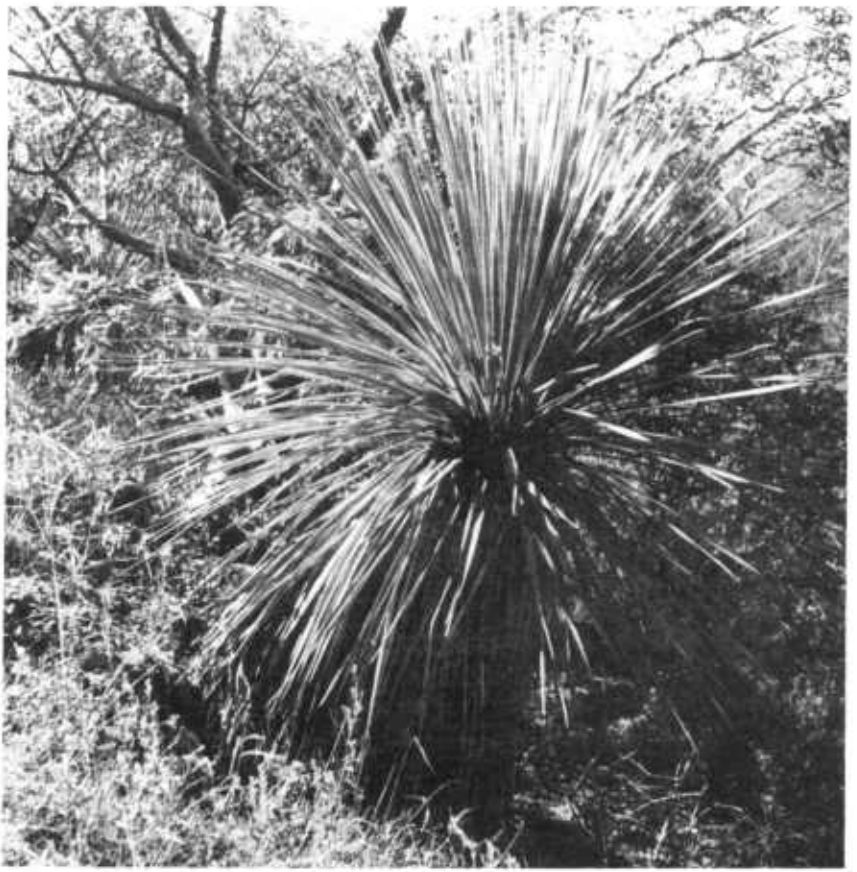
DASYLIRION ZUCC. EX OTTO & DIETR., ALLG. GARTENZEITUNG 6: 258. 1838.

Short, arborescent perennials with thick single stems crowned with dense rosettes of serrulate or prickly, linear, hard fibrous leaves; inflorescence dioecious, narrowly paniculate, elongate, conspicuously bracteate; pedicels jointed at base of flowers; flowers small, whitish, persistent, congested, on ascending lateral branches; stamens 6, vestigial on pistillate flowers; ovary 3–celled, 3–ovuled, 2 aborting; stigmas 3 in apical notch of ovary; capsules 1–seeded, small, 3–winged, thin-walled. The only general account of this genus is that written by Trelease in 1911 (*49*).

Dasylirion wheeleri S. Wats. ex Rothr., in Wheeler, U.S. Survey West 100th Meridian Rpt. 6: 378. 1878.

Bushy perennial with stocky stems 0.5–1.5 m. tall, skirted by persistent, dry, declined leaves; leaves 1.5–3 cm. broad above flaring clasping bases, 6–10 dm. long, numerous, armed with sharp slender, straight to antrorse teeth, yellow to brownish, 2–5 mm. long, 5–15 mm. apart; panicles slender, 3–4 m. long, the peduncle extending above the leaves; flowers on numerous, ascending, short lateral branches, subtended by broad, scarious, fimbriate bractlets; laterals of the staminate flowers longer (6–9 cm. long) and more densely flowered than the fruiting laterals; fruit obovate, 5–6 mm. wide, 6–7 mm. long, the apical notch about 1 mm. deep, apices of the wings acute to obtuse, seed 3.5–4 mm. long, brownish; flowers May-August. (Fig. 69.)

Type—Ash Creek, Ariz., *Rothrock 329* and *655*. SONORA: El Rancho del Roble, northeast of El Tigre (Loop of the Rio Bavispe), alt. 6,000 feet, Sept. 2–13, 1941, *White 4216* (fr.); western foothills of Sierra de la Caballera, about 10 miles east of Colonio Morelos, alt. 3,400 feet, Sept. 22, 1941, *White 4480* (fr.); Arroyo de la Galera, *White 3064;* Canyon de Bavispe in oak grassland, *White 3234;* Santa Rosa Canyon near Bavispe, *White 575*. Sierra Charuco, Sonora-Chihuahua boundary, pine-oak forest, Sept. 13, 1935, *Gentry 1822*. Cerro Jojoba, about 50 miles south of Caborca, May 20, 1963, *Felger & Gentry 7868* (lf.); 15.4 miles southeast of Magdalena on road to Cucurpe, alt. about 3,400 feet, *Felger 3459*. Widely scattered in oak woodland and pine-oak forests at elevations between 3,000 and 6,000 feet. The western geo-



PN–2176

FIGURE 69.—*Dasylirion wheeleri* on Sierra Charuco. Thick trunk is hidden by dry, persistent leaves.

graphic limit is on Sierra del Viejo in northwestern Sonora, east to western Texas and Chihuahua.

The only other plant with which this species may be confused in our area is *D. leiophyllum* Engelm. ex Trel. The latter, however, can be distinguished quickly by the teeth that bend downward rather than upward on the lower half of the leaves. There is no record of *D. leiophyllum* in Sonora, but it may yet be found in northeastern Sonora adjacent to New Mexico and Chihuahua.

D. wheeleri is commonly known by an Indian name "sotol." Some tribes, however, have quite different names for it; the Warihio call it "sawo" (*13*). The Indians have many uses for this plant. The leaves were employed for thatching and for mats and baskets after the teeth were stripped off. The trunks are now employed

for posts in houses and corals. The fiber in the tender leaf buds is used as cordage. Like many other members of the Agavaceae, the soft meristematic tissue in the stem of *D. wheeleri* is cooked for food and drink. The hard liquor "sotol" is distilled and consumed locally. It is of inferior quality, having a strong taste and leaving a raspy feeling in the throat after swallowing. Some individuals, addicted to its use, stink like the primitive stills in which it is made. Standley reported (*43*) that the trunks are sometimes used as cattle feed. After the leaves are burned off, the trunks are split open to permit hungry cattle to eat the spongy interior.

Except in botanical gardens, *D. wheeleri* is infrequent in cultivation. However, because of its singular rosette appearance, drought resistance, cold hardiness, and long life, it would be adorning and suitable for landscaping public buildings and highways in our Southwest. The lower part of the leaves with their broad, flaring, white bases are frequently seen in southwestern novelty stores as decoration arrangements and are known as "desert spoons."

NOLINA MICHX., FLORA BOREALA AMER. 1: 208. 1803.

Acaulescent or arborescent perennials with the trunk sometimes swollen at base or below ground; leaves linear, hard, fibrous, rough or serrulate on margins; inflorescence a diffuse racemose panicle, the branches subtended by bracts; bractlets minute, scarious, more or less lacerate-cilate; pedicels jointed; perianth 6-merous, small, persistent, spreading; stamens 6, usually abortive in fertile flowers; filaments short, slender, or dilated at base; ovary sessile or short-stipitate and abortive in flowers with fertile stamens, deeply 3–lobed; style very short; ovules 2 in each cell; fruit a papery tripartite capsule, tardily dihiscent or rupturing; seeds 1–3 in a capsule, globose to oblong, light-colored.

The species in this genus are not well known and there are problems in specific relationships. The record of the genus in Sonora is feeble, as shown by the paucity of specimens cited below. I have included two taxa, *Nolina bigelovii* and *N. texana compacta*, which apparently have not been collected within Sonora, but which have been collected along the Arizona-Sonora boundary. There is little doubt that they occur in Sonora. A systematic revision of this genus would be an excellent Ph.D. thesis for a student and would fill a present void in the taxonomy of the Agavaceae. The last general treatment was by Trelease, "The Desert Group Nolineae," published in 1911 (*49*). The genus consists of about

20 species and is best developed in Mexico, but several species occur across Southern United States from California to Florida. Plants with well-developed trunks, 1–several m. tall; leaves 10–35 mm. wide.

Trunks slender above the base and branched; leaves mostly 10–15 mm. wide at base, persistent serrulate; capsules much broader than long, 8–9 × 5 mm.; seeds globose, dark gray, eastern Sonora ---------- *matapensis*, below.

Trunks short and thick, unbranched; leaves mostly 2–2.5 cm. wide, at first serrulate, then filiferous; capsules as long as broad, 8–12 mm.; seeds ovate to oblong, whitish, northwestern Sonora. *bigelovii*, p. 180.

Plants acaulescent; leaves usually less than 12 mm. wide.

Panicles elongate, about equaling the leaves; capsules inflated, the seed not protruding early; bracts subtending lower branches shorter than the branches ---------- *microcarpa*, p. 181.

Panicles short, within the rosette; capsules not inflated, early ruptured by growing seed; lower bracts long caudate, surpassing the lower branches ---------- *texana compacta*, p. 182.

***Nolina matapensis* Wiggins, Dudley Herbarium Contrib. 3: 65. 1940.**

Small trees with simple or 3- to 4-branched trunks, dilated at base, with checked bark and rather small leaf crowns; leaves linear, 10–15 mm. wide near base, 7–12 dm. long, recurving, hard, striate, greenish yellow and somewhat glaucous, finely serrulate on margins; panicles 1.5–3 times longer than the leaves and variously angled from the stem apex; primary branches of the panicles 15–35 cm. long; branchlets mostly 10–15 cm. long; pedicels filiform, 8–10 mm. long, jointed 1–2 mm. above base; perianth segments oblong-linear, 2 mm. long, the outer spreading, inner more erect; capsule much broader than long, 5 × 8–9 mm., depressed, the apical notch very broad, the wall thin, tardily dehiscent; seeds pale brownish, nearly round, 2.5–3 mm. in diameter; flowers–May.

Type—Near Matapé, between Hermosillo and Suaqui, Sonora, Sept. 29, 1934, *Wiggins 7515*, in Dudley Herbarium No. 266078. (A specimen of this number in U.S. Natl. Herbarium is labeled "Gravelly washes and hills near Matapé.") SONORA: 9 miles northeast of Matapé on road to Batuc, north pass in Sierra Batuc, alt. 3,510 feet, Sept. 9, 1941, *Wiggins & Rollins 439* (fr.); same locality, Sept. 29, 1934, *Shreve 6786* (lf. & fr.); 20 miles southeast of Cananea, May 8, 1948, *Wiggins 11699* (fl.); Sierra Tecurahui, southeast Sonora, in pine-oak forest, alt. 4,000 to 4,500 feet,

Oct. 26–28, 1961, *Gentry, Barclay, & Arguelles 19429* (fr.); Sierra Orejon, Rio Mayo, Sonora-Chihuahua border, on oak slope, Jan. 1, 1935, *Gentry 1209* (fr.); El Rancho Roble, northeast of El Tigre, alt. 6,000 ft., Sept. 2–13, 1941, *White 4200* (lf. & fr.). Occurs in open stands widely scattered on grassy slopes in oak woodland and with the lower pines at elevations between 3,000 and 5,500 feet; southeast Sonora and adjacent Chihuahua. (Fig. 70.)

N. matapensis is not likely to be confused with any other plant in Sonora when it is observed in its native habitat. Its narrow leaves and small flowers and capsules distinguish it from the tree yuccas, the only other arborescent members of the family in eastern Sonora. Its near relative *N. microcarpa* (fig. 72, *upper*) is

PN–2177

FIGURE 70.—*Nolina matapensis* on mountain above Guasaremos, Chihuahua. Plants are partly screened by *Ipomoea chilopsis* and oaks, but black trunk shows at base of photo.

trunkless and resembles coarse clumps of bunchgrass. However, herbarium collections may be hard to separate because there is some overlap in the relative length of pedicels and thickness of capsule walls. A collector's note on plant habit would facilitate identification of herbarium specimens.

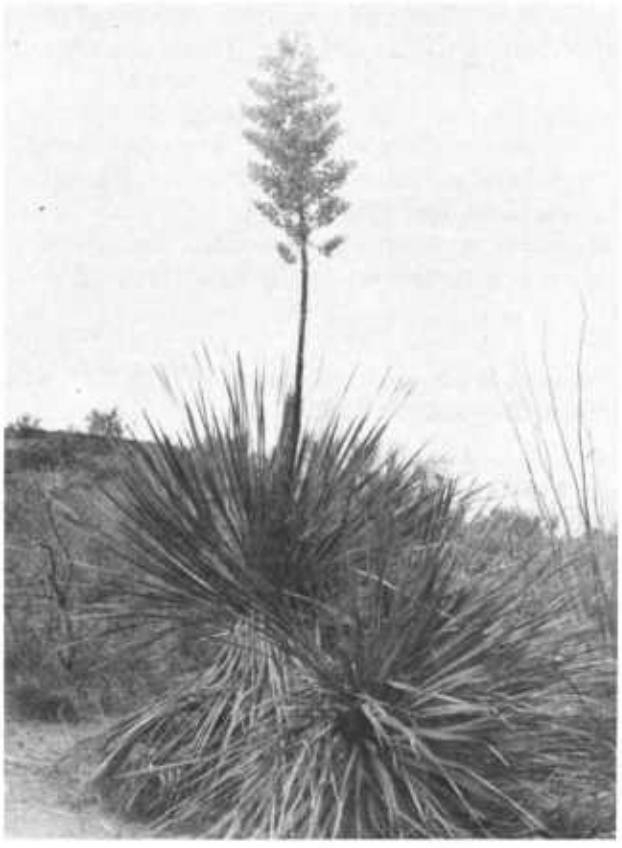
N. matapensis is generally called "palmita" or "palmito," but the Warihio name is "tuya." They use the new leaves in the long, conic, terminal buds for weaving baskets. The trunks may be used locally for posts. As far as I know, this tree has never been brought into horticulture. It could perhaps be used to advantage for landscaping in the semiarid southwestern areas. Nothing is known about the longevity of the trees nor the reproductive cycle. It seeds very well in certain years.

***Nolina bigelovii* (Torr.) S. Wats., Amer. Acad. Arts Proc. 14: 247. 1879.**

***Dasylirion bigelovii* Torr., U.S. Exploration Miss. Pacific Rpt. 4: 151. 1857.**

Coarse truncate plants 1–3 m. tall with a large crown of stiff leaves persisting dry and reflexed on trunk; leaves 80–120 × 15–35 cm., linear, at first serrulate then filiferous; panicles 6–10 dm. long; bracts deltoid-lanceolate, thin, 4–10 × 1–2 cm., attenuate, soon deciduous; primary branches of the inflorescence slender 10–20 cm. long, ascending, glabrous, smooth, the secondaries much shorter; bractlets chartaceous, lacerate; perianth segments oblong-linear, 2.5–3 mm. long, the outer introrsely short-apiculate, reflexed in pistillate flowers, the inner erect or ascending; filaments of abortive stamens dilated below; stigma lobes sessile, capsule narrowly emarginate at apex and base, 8–12 × 9–12 mm.; seeds ovate to oblong, 2.5–3.5 mm. long, whitish, coat wrinkled.

Type—*Biglow 1553–4,* Bill Williams Fork, Ariz. Trelease (*47*) doubtfully referred *Schott 1441* from an unspecified locality in Sonora to this species—"with fruit scarcely 8 mm. in diameter." The following specimens are from the Arizona-Sonora border and indicate this species in northwestern Sonora. ARIZONA: Tinajas Altas, Yuma County, Mar. 21, 1933, *Shreve 6233;* same locality, *Kearney & Peebles 10911;* arroyo head, Tule Tank Canyon, Cebeza Prieta Range, Yuma County, Apr. 14, 1947, *Tinkham s.n.;* Tule Mountains, Mexican boundary line, Feb. 11, 1894, *Mearns 2797.* On rocky slopes and gravelly bajadas of mountains in northern part of the Sonoran Desert. Although *Nolina bigelovii* presents a rank growth aspect, it is one of the most xerophytic of the nolinas. (Fig. 71.)



PN–2178

FIGURE 71.—*Nolina bigelovii* in western Arizona near type locality. The two large flowering plants in foreground are about 9 feet tall.

Nolina microcarpa **S. Wats., Amer. Acad. Arts Proc. 14: 247. 1879.**

Acaulescent cespitose perennial forming large, dense, grasslike clumps; leaves 6–12 mm. wide, 6–12 dm. long, linear, arching, serrulate on margins, flat keel beneath, the tips spliting into brushlike tufts; panicle 1 m. or more long, the lateral branches 15–50 cm. long with numerous branchlets about ½ as long; bractlets 1–2.5 mm. long, fimbriate; pedicels slender, 4–5 mm. long; perianth segments 1.5–2 mm. long, lance-oblong, spreading, whitish; capsule subglobose, 4–5 mm. long, 6–7 mm. broad, deeply notched at apex, papery, the walls rupturing at maturity; seeds ovoid to obovoid, 3–3.5 mm. in diameter, light brown, finely wrinkled.

Type—Rocky Canyon, Ariz., *Rothrock 278*. SONORA: Tepopa, Sierra Saguaribo, June 4, 1936, *Gentry 2228;* mainly in grama

grassland in oak woodland at elevations between 3,500 and 5,500 feet, from western Arizona to western Texas and adjacent Mexico. (Fig. 72.)

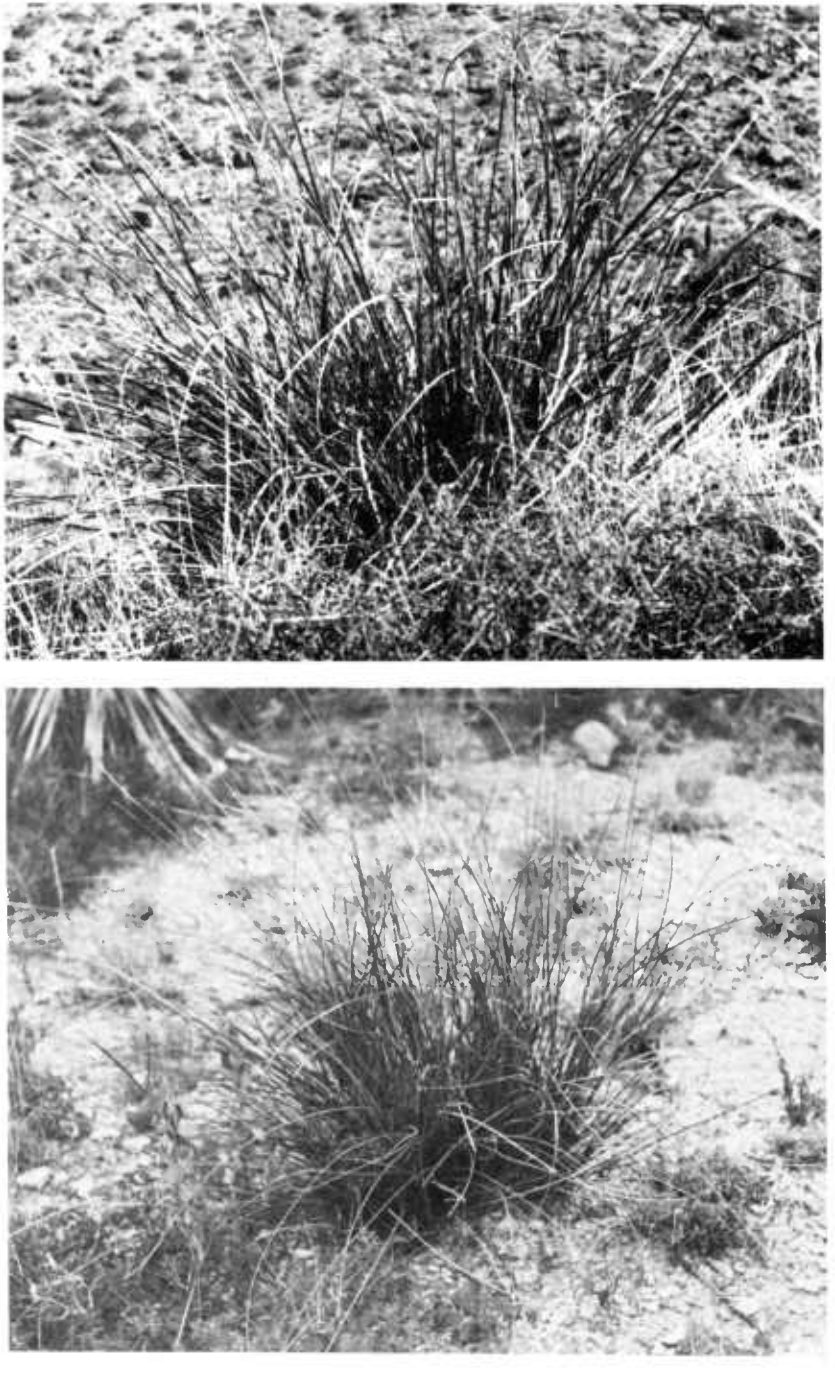
"Bear grass" in the wild pasture lands of Arizona and New Mexico is familiar to every stockman. The only name I have for the plant in Sonora is "sotol chiquito" in the Rio Mayo country. It is very rare there and this name sounds quite spurious. It is probably abundant in northeastern Sonora, and the lack of specimens again calls attention to the general lack of botanizing in that region.

Nolina texana S. Wats., var. *compacta* (Trel.) I.M. Jtn., Arnold Arboretum Jour. 24: 90. 1943.

Nolina erumpens compacta **Trel., Amer. Phil. Soc. Proc. 50: 418. 1911.**
N. texana **S. Wats., Amer. Acad. Arts Proc. 14: 248. 1879.**
N. caudata **Trel., Amer. Phil. Soc. Proc. 50: 417. 1911.**

Acaulescent, low, spreading, cespitose, grasslike perennial; leaves narrowly linear, 70–120 × 0.3–0.4 cm., deeply rounded below, margins somewhat serrulate or sometimes smooth; panicle short, slender, 4–5 dm. long, the primary branches 10–15 cm. long, slightly scaberulose in lines; branchlets 2–5 cm. long; bracts caudate-attenuate, surpassing the branches, dry, yellowish, persisting; capsules 4–5 mm. high, 5–7 mm. wide, ruptured early by enlarging seeds; seeds globose, 3 mm. in diameter.

Type—Vincinity of New Braunfels, Tex., *Lindheimer 550 in 1846* and *712 in 1847*. Several Arizona collections show this plant near the Sonoran border: Mule Mountains, Cochise County, July 20, 1894, *Toumey, s.n.* (type of *N. caudata* Trel.); Monument No. 40, Mexican Boundary line, May 9, 1892, *Mearns 258* (lf. & fl.); cited by Trelease (loc. cit.) from Nogales are *Ferris 1902, Coville 1624 in 1903,* and *Thompson 1911*. These localities are all in the oak woodland-grama grassland community that characterizes both sides of the border from Nogales eastward. It is remarkable to find no collections of this plant during the last 50 years in Arizona and Sonora. It should be looked for and collected in both the United States and Mexico; flowers May–June. (Fig. 72.)



PN–2179, PN–2180

FIGURE 72.—*Upper, Nolina microcarpa* in Harquahala Mountains of western Arizona; *lower, Nolina texana* near Comstock, Tex., along highway 90.

LITERATURE CITED

(1) ANDERSON, EDGAR.
1949. INTROGRESSIVE HYBRIDIZATION. 109 pp. John Wiley & Sons, New York.

(2) BAKER, J. G.
1888. HANDBOOK OF THE AMARYLLIDEAE. 216 pp. London.

(3) BELL, W. H., and CASTETTER, E. F.
1941. ETHNOBIOLOGICAL STUDIES IN THE AMERICAN SOUTHWEST. VII. THE UTILIZATION OF YUCCA, SOTOL, AND BEARGRASS BY THE ABORIGINES IN THE AMERICAN SOUTHWEST. N. Mex. Univ. Bul. 372, Biol. Ser. 5, 74 pp.

(4) BENNETT, W. C., and ZINGG, R. M.
1935. THE TARAHUMARA, AN INDIAN TRIBE OF NORTHERN MEXICO. 412 pp. The University of Chicago Press, Chicago.

(5) BERGER, ALWIN.
1915. DIE AGAVEN. 285 pp., illus. Jena. Verlag von Gustav Fischer.

(6) BREITUNG, A. J.
1968. THE AGAVES. Cactus and Succulent Jour. Yearbook. 107 pp. [Reprint from Cactus and Succulent Jour. vols. 31–38.] Abbey Garden Press, Reseda, Calif.

(7) CAMP, W. H., and GILLY, C. L.
1943. THE STRUCTURE AND ORIGIN OF SPECIES. Brittonia 4: 325–385.

(8) CASTETTER, E. F., BELL, W. H., and GROVE, A. R.
1938. THE EARLY UTILIZATION AND DISTRIBUTION OF AGAVE IN THE AMERICAN SOUTHWEST. Univ. N. Mex. Bul. 335, 92 pp.

(9) CORRELL, D. S., SCHUBERT, B. G., GENTRY, H. S. and HAWLEY, W. O.
1955. THE SEARCH FOR PLANT PRECURSORS OF CORTISONE. Econ. Bot. 9:307–375.

(10) CRUSE, R. R.
1949. A CHEMURGIC SURVEY OF THE DESERT FLORA IN THE AMERICAN SOUTHWEST. Econ. Bot. 3:111–131.

(11) EHRLER, W. H.
1967. AGAVE PLANT, EFFICIENT WATER USER. U.S. Dept. Agr. Agr. Res. 16 (4): 11.

(12) ENGELMAN, GEORGE.
1875. NOTES ON AGAVE. Acad. Sci. St. Louis Trans. 3: 291–322.

(13) GENTRY, H. S.
1942. RIO MAYO PLANTS. Carnegie Inst. Wash. Pub. 527, 328 pp.

(14) ———
1949. LAND PLANTS OF THE CALIFORNIA GULF REGION. Allan Hancock Foundation. Pacific Expeditions 13: 81–180.

(15) ———
1963. THE WARIHIO INDIANS OF SONORA-CHIHUAHUA: AN ETHNOGRAPHIC SURVEY. Bur. Amer. Ethnographic Bul. 186: 61–144, pls. 28–38.

(16) ———
1967. PUTATIVE HYBRIDS IN AGAVE. Jour. Hered. (Washington) 58: 32–36.

(17) GONCALVES DE LIMA, OSWALDO.
1956. EL MAGUEY Y EL PULQUE. 278 pp., illus. Fonda de Cultura Economica, Mexico.

(18) GRANICK, ELSA B.
1944. A KARYOSYSTEMATIC STUDY OF THE GENUS AGAVE. Amer. Jour. Bot. 31: 283–289.

(19) GRANT, VERNE.
1963. THE ORIGIN OF ADAPTATIONS. 606 pp. Columbia Univ. Press, New York.

(20) HARLAN, J. R., and DEWET, J. M. J.
1963. THE COMPILOSPECIES CONCEPT. Evolution 17: 493–497.

(21) HARRINGTON, M. R.
1933. GYPSUM CAVE, NEVADA. Southwest Museum Papers, Southwest Museum, Los Angeles.

(22) HODGE, CARL, ed.
1963. ARIDITY AND MAN. Amer. Assoc. Adv. Sci. Pub. 74: 309–337. [Especially, AGAVE USES, pp. 325–326; and A. SISALANA, A. ATROVIRENS, A. VILMORINIANA, A. LECHEGUILLA. STEROIDS & FIBERS, YUCCA, p. 326.]

(23) HOYER, B. H., MCCARTHY, B. J., and BOLTON, E. T.
1964. A MOLECULAR APPROACH IN THE SYSTEMATICS OF HIGHER ORGANISMS. Science 144: 959–967.

(24) JACOBI, G. A.
1864. VON VERSUCH ZU ENNER SYSTEMATISCHEN ORDNUNG DER AGAVEEN. 296 pp. Hamburg. Separabdruck der Hamberger Garten- und Blumenzeitung.

(25) ———
1864–68. Hamburger Garten- und Blumenzeitung. [This is (*24*) in serial journal form. The later years contain supplementary notes to his Systematischen Ordnung Agaveen; plant species entered by numbers referring to those as given originally in book. Additional species are given A and B numbers.]

(26) ———
1868. NACHTRAGE I ZU DEM VERSUCH ZU ENNER SYSTEMATISCHEN ORDNUNG DER AGAVEEN. pp. 138–174.

(27) ———
1870. NACHTRAGE II OR ZWEITER NACHTRAGE ZU DEM VERSUCH ZU ENNER SYSTEMATISCHEN ORDNUNG DER AGAVEEN. pp. 147–175.

(28) JACOBSEN, J.
1960. HANDBOOK OF SUCCULENT PLANTS. 1: 64–130. Blandford Press. [An English translation of Berger's work, but without his keys and only partial descriptions. Cites some additional horticultural names, but not the later species of Trelease and other American authors.]

(29) JOHNSTON, I. M.
1924. EXPEDITION OF THE CALIFORNIA ACADEMY OF SCIENCES TO THE GULF OF CALIFORNIA IN 1921—THE BOTANY. Calif. Acad. Sci. Proc. 12: 951–1218.

(30) KEARNEY, T. H., and PEEBLES, R. H.
1942. FLOWERING PLANTS AND FERNS OF ARIZONA. U.S. Dept. Agr. Misc. Pub. 423, 1069 pp.

(31) LANGMAN, IDA K.
1964. A SELECTED GUIDE TO THE LITERATURE ON THE FLOWERING PLANTS OF MEXICO. 1015 pp. Univ. Pennsylvania Press.

(32) LITTLE, ELBERT.
1943. *In* Benson, Revision of Status of Southwestern Desert Trees and Shrubs. Amer. Jour. Bot. 30: 235.
(33) MCKELVEY, SUSAN D.
1938 and 1947. YUCCAS OF THE SOUTHWESTERN UNITED STATES. Part I and Part II, respectively. Illus. Arnold Arboretum, Jamaica Plains, Mass.
(34) MAYR, ERNST.
1959. ISOLATION AS AN EVOLUTIONARY FACTOR. Amer. Phil. Soc. Proc. 103: 221–230.
(35) ———
1966. ANIMAL SPECIES AND EVOLUTION. 797 pp. Harvard Univ. Press, Cambridge, Mass.
(36) ——— and others.
1957. THE SPECIES PROBLEM. Amer. Assoc. Adv. Sci. Pub. 50, 395 pp. Washington, D.C.
(37) MILLER, C. D., and HAMILTON, R. A.
1956–60. THE DEANS REVIEW. MORE FOOD FOR THOUGHT. Hawaii Farm Science.
(38) PENNINGTON, C. W.
1958. TARAHUMAR FISH STUPEFACTION PLANTS. Econ. Bot. 12: 95–102.
(39) SCHUCHERT, CHARLES.
1935. HISTORICAL GEOLOGY OF THE ANTILLEAN—CARIBBEAN REGION. 811 pp. John Wiley & Sons, New York.
(40) SHARMA, A. K., and BHATTACHARYYA, U. C.
1962. A CYTOLOGICAL STUDY OF THE FACTORS INFLUENCING EVOLUTION IN AGAVE. Cellule 52: 259–281.
(41) SHREVE, FORREST.
1936. PLANT LIFE IN THE SONORAN DESERT. Sci. Monthly 42: 195–213.
(42) ——— and WIGGINS, I. L.
1964. VEGETATION AND FLORA OF THE SONORAN DESERT. 2 v. Stanford Univ. Press.
(43) STANDLEY, P. C.
1920–26. TREES AND SHRUBS OF MEXICO. Contrib. U. S. Natl. Herbarium 23: 87–142.
(44) STEBBINS, G. LEDYARD.
1950. VARIATION AND EVOLUTION IN PLANTS. 643 pp. Columbia Univ. Press.
(45) ———
1959. GENETICS AND TWENTIETH CENTURY DARWINISM. Cold Springs Harbor Symposia on Quantitative Biology 24: 1–311. [Especially, THE SYNTHETIC APPROACH TO PROBLEMS OF ORGANIC EVOLUTION, pp. 305–311.]
(46) TRELEASE, WILLIAM.
1902. THE YUCCEAE. Mo. Bot. Gard. Ann. Rpt. 14: 27–133, 99 pls.
(47) ———
1910. SPECIES IN AGAVE. Amer. Phil. Soc. Proc. 49: 232–237.
(48) ———
1911. THE SMALLEST OF THE CENTURY PLANTS. Reprint from the Popular Scientific Monthly, January 1911. 15 pp.

(49) ———
1911. THE DESERT GROUP NOLINEAE. Amer. Phil. Soc. Proc. 50: 404–443.
(50) ———
1913. AGAVE IN THE WEST INDIES. Natl. Acad. Sci. Biog. Mem. 11, 298 pp., 116 pls.
(51) TURNER, R. M., ALCORN, S. M., OLIN, GEORGE, and BOOTH, J. A.
1966. INFLUENCE OF SHADE, SOIL, AND WATER ON SAGUARO SEEDLING ESTABLISHMENT. Bot. Gaz. 127: 95–102.
(52) WALL, M. E., and others.
1954. STEROIDAL SAPOGENINS. VII. U.S. Dept. Agr. AIC-363, 25 pp. [Processed.]
(53) ——— and others.
1954. STEROIDAL SAPOGENINS. VII. SURVEY OF PLANTS FOR STEROIDAL SAPOGENINS AND OTHER CONSTITUENTS. Jour. Amer. Pharm. Assoc. 43: 1–7.
(54) ——— and others.
1954. STEROIDAL SAPOGENINS. XII. Jour. Amer. Pharm. Assoc. 43: 503–505.
(55) ——— and others.
1954. STEROIDAL SAPOGENINS. XV. U.S. Dept. Agr. AIC-367, 32 pp. [Processed.]
(56) ——— and others
1955. STEROIDAL SAPOGENINS. XXVI. U.S. Dept. Agr. Agr. Res. Serv. ARS-73-4, 30 pp.
(57) WEBBER, J. M.
1953. YUCCAS OF THE SOUTHWEST. U.S. Dept. Agr. Agr. Monograph 17, 97 pp., 72 pls.
(58) WHITE, S. S.
1948. THE VEGETATION AND FLORA OF THE REGION OF THE RIO BAVISPE IN NORTHEASTERN SONORA. Lloydia 11: 229–302, illus.
(59) WILSON, I. F., and ROCHA, V. S.
1949. COAL DEPOSITS OF THE SANTA CLARA DISTRICT, NEAR TONICHI, SONORA, MEXICO. U.S. Geol. Survey Bul. 962-A, 80 pp., illus.
(60) WOLF, C. B.
1935. CALIFORNIA PLANT NOTES. Rancho Santa Ana Occas. Papers Ser. 1 (1): 31–42.

GLOSSARY OF SPECIAL TERMS

abaxial, the side of a lateral organ away from the central axis.
acaulescent, stemless or without visible stem below the leaves.
acicular, needle-shaped.
adaxial, the side of a lateral organ next to the central axis.
adventitious buds, those produced in areas without visible bud initials, as from the stem instead of the axils of the leaves.
allopatric, applied to allied species or populations inhabiting separate geographic areas. Compare sympatric.

antrorse, directed forward or towards the apex, as the prickles on a leaf margin.
arcuate, moderately arched or curving.
ascending, of leaves pointed upward and outward at about 20° or more from the horizontal.
attenuate, gradually narrowed or prolonged.
bud printing, of leaves when the margin of one leaf is impressed upon the surface of the next leaf.
bulbiferous, producing bulbils.
bulbil, small plant reproduced vegetatively in the axils of the inflorescence. A form of asexual reproduction.
cabeza, Spanish, head, applied to the thick, short stem of agaves.
campanulate, bell-shaped.
castaneous, chestnut-colored.
caulescent, having a stem or trunk below the leaves.
cespitose, as applied to succulents, growing in clusters by the production of basal branches, suckers, or offsets.
chartaceous, papery, dry, and thin.
circadian (L. circa, about & dies, day), relating to biologic variations or rhythms with a cycle of about 24 hours.
clone, a group of individual plants reproduced asexually from a single original parent.
conduplicate, folded together lengthwise.
conic, cone-shaped.
contingent perennial, a plant living more than 2 years and whose flowering is contingent upon the proper climatic conditions, i.e., rainfall and higher temperature.
crenate, applied to leaf margin strongly and abruptly undulate with large teats.
cucullate, hooded at the apex.
cultigen, a plant known to exist only in cultivation. Compare cultivate.
cultivate, as a noun, a cultivated plant with known wild ancestors.
deflexed, bent downward.
descending, of leaves, directed below the horizontal.
ensiform, sword-shaped.
explanate, flattened, spread out flat.
exserted, exceeding the corolla, as the filaments extending beyond the tepals.
filiferae, threadlike structures along the leaf margins.
filiferous, having threadlike structures.
friable, said of teeth or leaf margins that are easily brushed or rubbed off.

funnelform, funnel-shaped.

glaucous, whitened with a waxy coating over the epidermis.

guttered, having the sides of the leaves raised to form a trough-shaped leaf, partly conduplicate.

haft, handle, applied to the narrowed lower part of the leaf, which is usually the least prickly part for grasping with the hand.

keel, the fleshy midrib on the tepal or the leaf.

laterals, the main branches of the paniculate inflorescence.

maguey, an American Indian name for agave. It was picked up by the earliest Spaniards and appears to have been in general use in the Caribbean region and Mexico. Cortes in "Historia de Mexico" wrote, "miel de unas plantas, que llaman en las otras, y estas maguey, que es muy mejor que arrope; y de estas plantas hacen azucar, y vino, que es asi mismo venden" (*17*).

mescal, an American Indian name applied to agave plants, to the cooked parts of the same, and to the distilled liquor made from the meristem. Used more in northern Mexico. Also applied loosely to *Manfreda, Tillandsia,* and other monocots.

metl, a Nahuatl name for agave, still in use among native tribal people in central Mexico; "papalo metl" (butterfly agave, *A. potatorum*), "tlaca metl" (*A. salmiana*).

monocarpic, a plant or rosette that flowers once and dies. Compare polycarpic.

multiperennial, a plant that flowers once and dies, but requires several to many years to mature.

neck, apical portion of ovary between the ovarian cells and the base of the tube. (See fig. 3, p. 22.)

panicle, the branched inflorescence of the subgenus *Agave* with flowers borne in umbellate clusters on lateral branches.

paniculate, like a panicle.

patulous, standing open, spreading.

plane, applied to leaves having the upper surface flattened as compared with guttered or explanate.

polycarpic, a plant or rosette that flowers repeatedly, but not necessarily every year. Compare monocarpic.

proterandrous, the condition of a perfect flower when the anthers dehisce before the pistil is receptive. Hence, the flower cannot normally be self-fertilizing.

pruinose, having a waxy exudate on the surface of the leaf.

pulque, the fermented juice of the larger agaves. Word derived from Nahuatl "poliuhqui" or "ocli poliuhqui," but which was applied to soured or spoiled "ocli," fid Nuñez Ortega, the chronicler of Hernando Cortes (*17*).

raceme, an inflorescence in which the flowers are borne on pedicels along a central axis.
reclinate, reclining, applied to leaves pressing downward upon lower leaves or on the ground.
recurved, recurvate, curved backward or downward.
reflexed, bent sharply downward.
retrorse, directed towards the base.
rhizome, underground stem or shoot.
rosette, a closely spaced group of radiating leaves limited to a portion of the stem, usually at the base of the inflorescence.
sapogenin, a compound derived by hydrolysis from saponin. A large group of such compounds have been found in plant tissues and named according to their specific molecular configuration, e.g., *diosgenin, smilogenin, hecogenin.*
shaft, in *Agave* the central axis of the inflorescence including the peduncle and the central rachis of the flowering portion or branches.
spike, an inflorescence with the flowers more or less sessile along a common or single peduncle or shaft.
spine, terminal spine, in *Agave* the pungent indurated tip of the leaf.
spreading, of leaves extending outward less than 20° from horizontal.
subulate, awl-shaped, long tapering.
surculose, producing suckers or offsets.
sympatric, applied to related species or populations inhabiting the same geographic area.
teat, fleshy prominences under the teeth on the leaf margins. (See fig. 26, p. 85.)
teeth, the prickles along the leaf edge.
tepal, a combination of sepal and petal, applied when the segments of the perianth are not differentiated into two dissimilar ranks, (common in monocotyledons).
trigonous, three-angled with plane faces.
tubular, tube-shaped.
umbel, a flat-topped or low-rounded flower cluster with the pedicels of unequal length from a common point, like an inverted umbrella.
umbellate, having the inflorescence in umbels or in similar form.
undulate, applied to leaf margins with low teats, wavy, as compared to straight margins.
urceolate, urn-shaped.
vallecullate, little valley-shaped, as applied to agaves having folds in the leaf towards apex, plicate.

INDEX

(Page number in boldface type indicates taxon description)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1972 O—413—066